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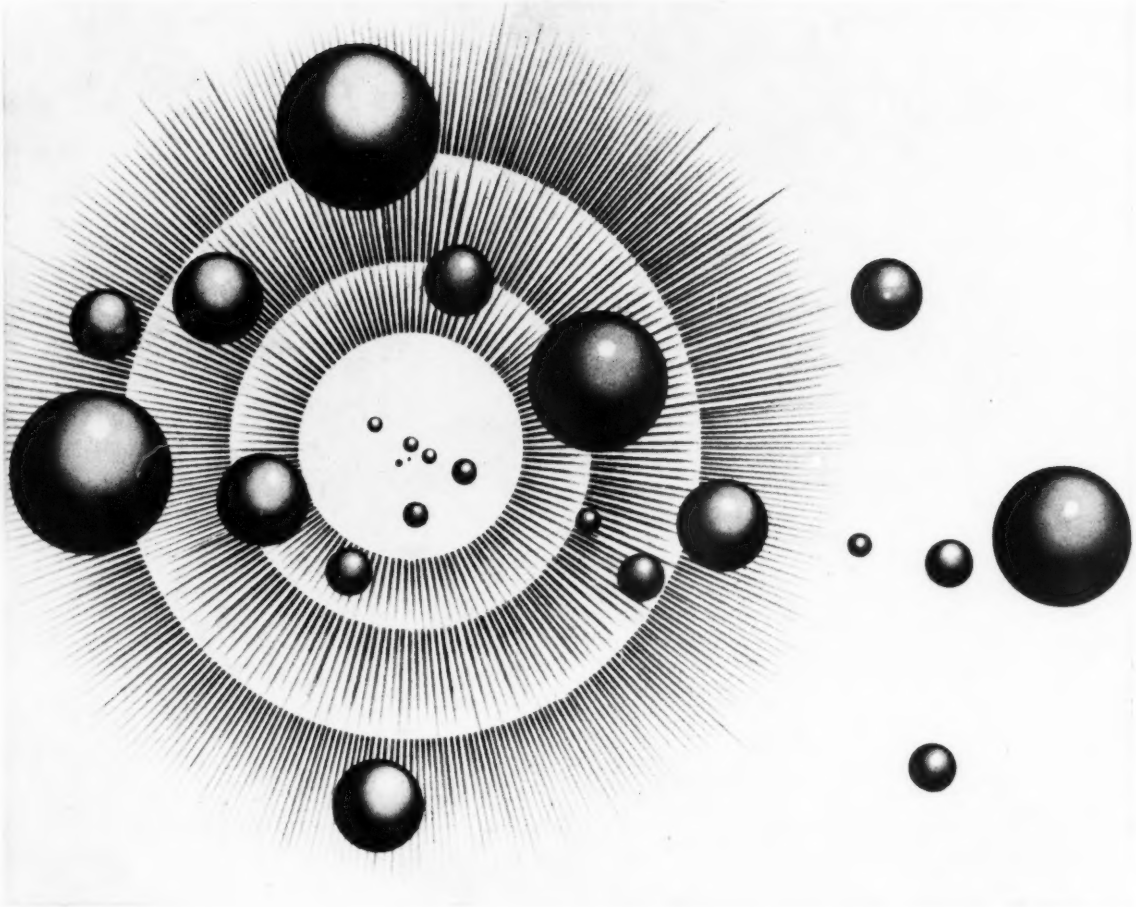

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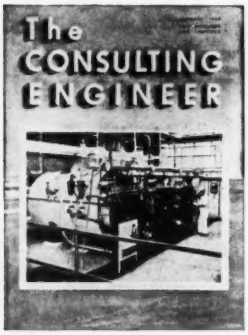

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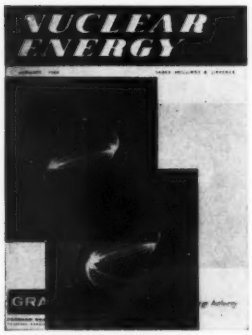

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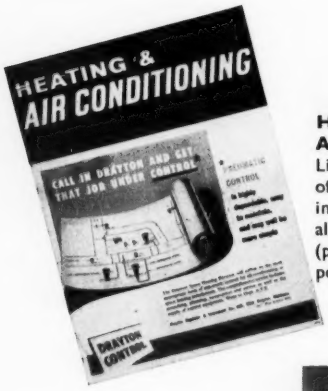

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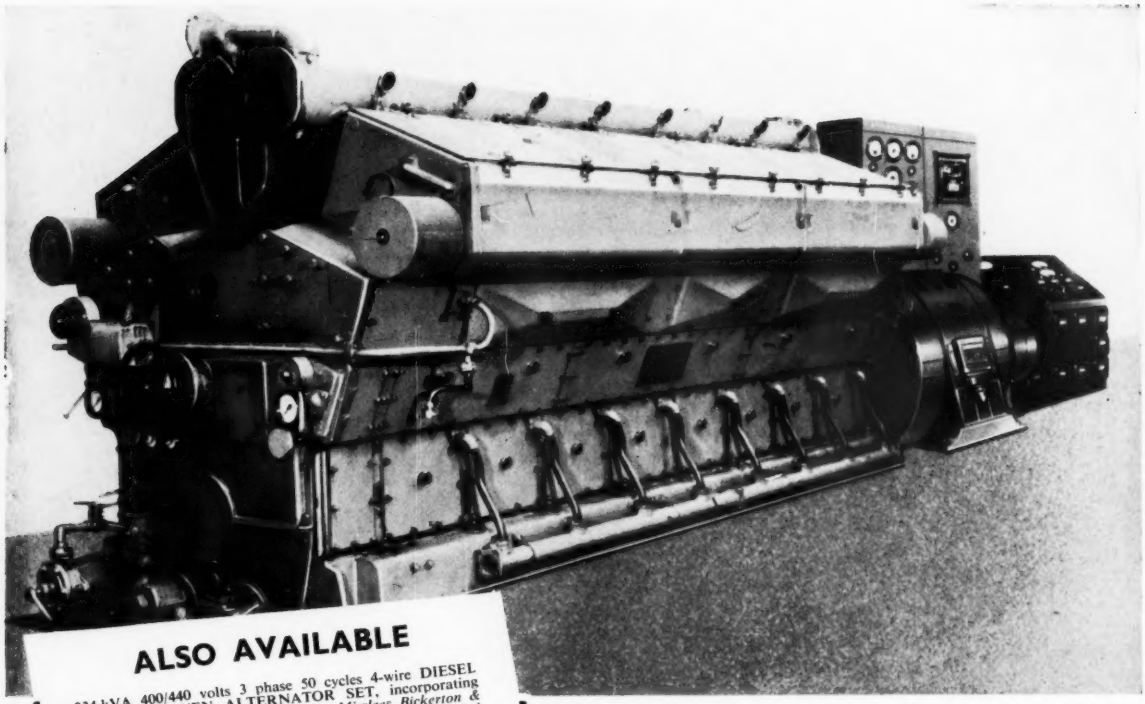

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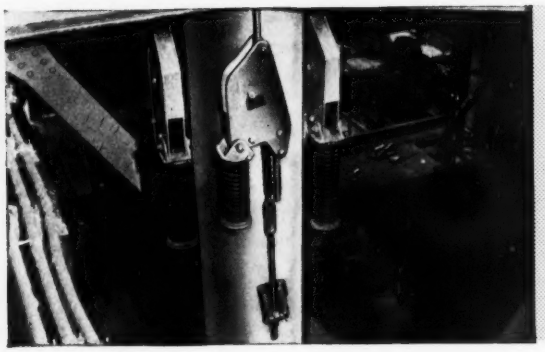

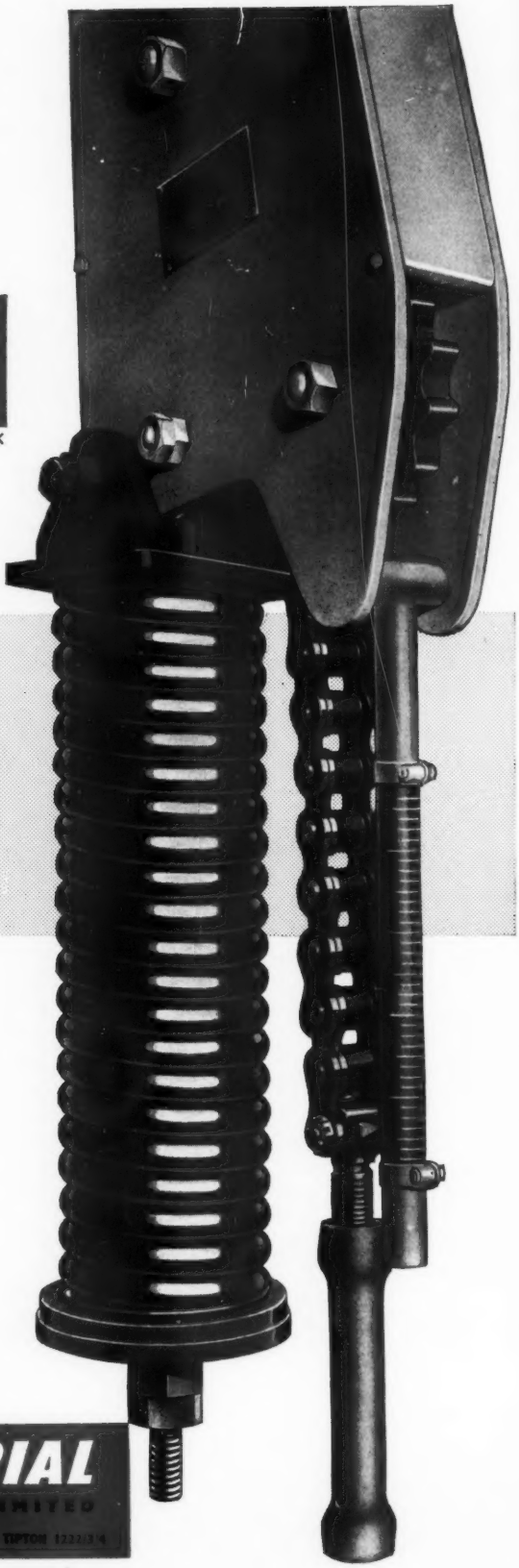

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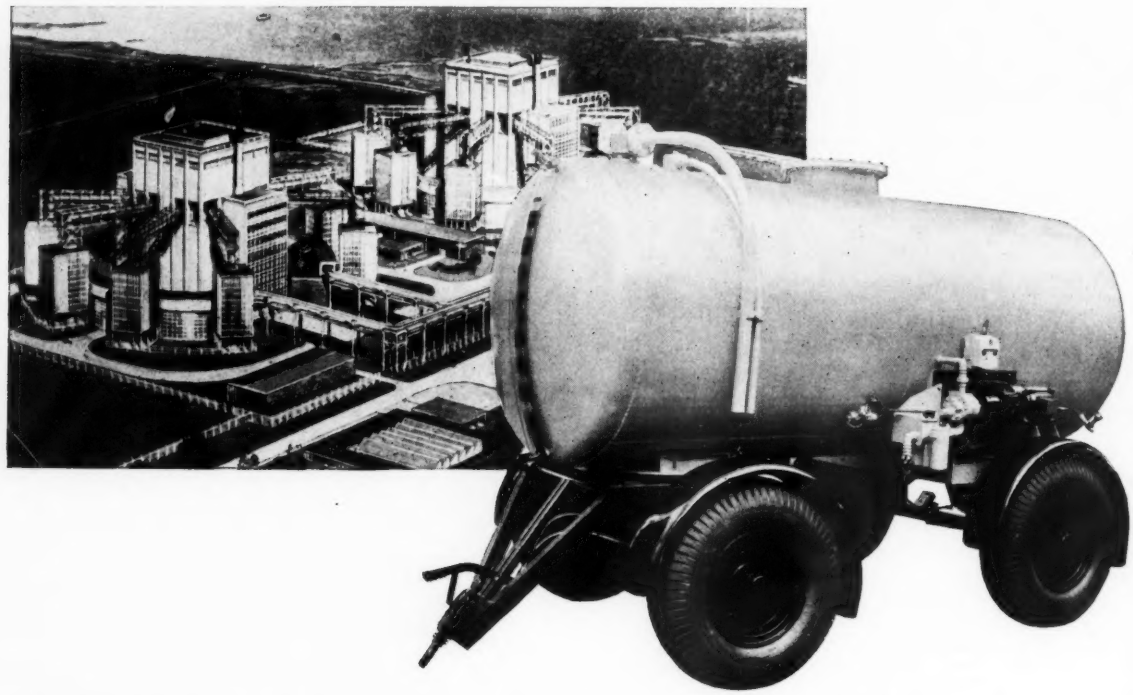

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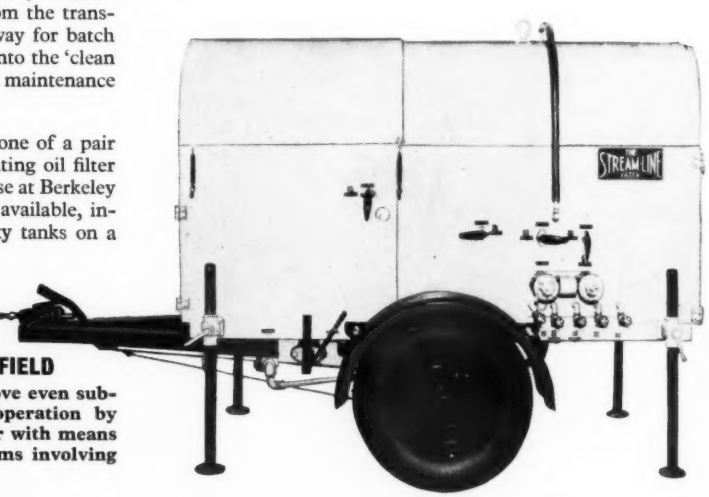

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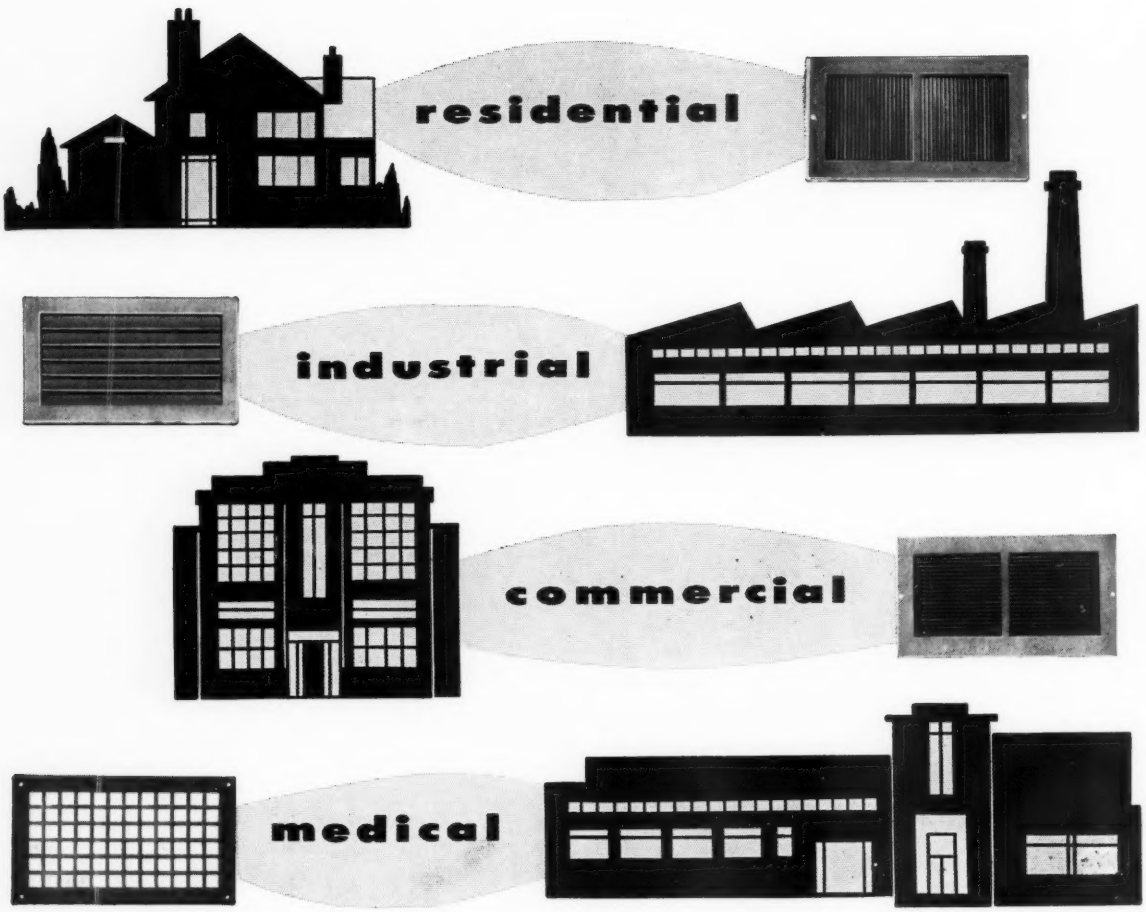

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NUCLEAR ENERGY

COMMENT

SHADES of the United Nations General Assembly fell on the fourth General Conference of the International Atomic Energy Agency when the Russian delegation repeatedly accused the Western powers of using the Agency for their own purposes. The American representatives met the charges with their usual bland air of superior adulthood tinged with a plutocratic if impatient benevolence. The United Kingdom attempted to calm the troubled air by politely admonishing the antagonists for dirtying the proceedings with politics and then going on to ignore the intrusion. From uncommitted India came some sense and dignity. Unfortunately, however, the suggestions of Dr. H. Bhabba, chairman of that country's young and virile atomic energy commission, were largely unheeded.

Professor V. S. Emelyanov, head of the Russian delegation, perhaps did not make such a spectacle of himself as did his master at New York. Nonetheless, his tactics of using the Agency as a blasting board against America were, to say the least, ill-mannered and ill-timed. For all that, it is not possible to completely disregard all that he said—there was some sound reason in some of his comments.

The principal quarrel was over the measures to be taken by the Agency in ensuring that countries using fissile material and reactor plant supplied through the help of the Agency do not divert these from their intended peaceful purposes to weapon production. The provision of such safeguards was written into the Agency's constitution right at its birth, in 1956. Since then experts of the secretariat have been studying the problems and techniques involved to evolve a system of safeguards which earlier this year won the approval of the board of governors.

Very briefly, the proposals call for regular stock and operational reports on materials and plant covered by the safeguards, and, in the case of reactors within a certain size range, regular inspection by Agency staff. To the Russians, the surveillance this implies smacks too much of interference in state sovereignty. Having somebody poking their nose in everything that is done, they maintain, is hardly conducive to progressive research. The Americans counter this by pointing to the very amicable relations they have experienced with countries with which they already have bilateral nuclear agreements. This, however, only adds to the gore of the Russians who see the turning over of the safeguard arrangements made under these bilateral agreements to the jurisdiction of the Agency, an action implicit in the Agency's constitution, merely as an example of America using the Agency to her own advantage.

It is of course difficult to take these particular Russian arguments seriously. On the other hand, there is one argument emanating from the Communist and non-committed sides which seems to warrant a second look.

There is every justification for the Agency knowing what happens to the materials and plant it supplies to member states, that they are not used for weapons. It can be seriously doubted, however, whether the proposed safeguards will in fact contribute much to the prevention of nuclear arming. Powers already in possession of atom bombs and weapons clearly have no need for the assistance of the Agency as regards the supply of materials and plant, so the question of inspections and reports in their case just does not arise. As intimated by Dr. Bhabba, other countries that have the necessary technical know-how, resources and inclination to make nuclear weapons would do so without the help of the Agency. Furthermore, those states that do make use of the services provided by the Agency are mainly those that have at present insufficient resources and know-how; by the time they have overcome these deficiencies they will lay less reliance on the Agency.

In the face of such arguments it is possible to wonder as to why the Agency has gone to all the trouble it has in drawing up such an elaborate regulatory system. As to the validity of such arguments one has only to point to the possibilities arising from the recently announced entry by Germany into the field of uranium isotope separation. The Americans were scared to death by the announcement and there was nothing the IAEA could do to help them!

If nuclear disarmament of any sort is to be achieved it ought to be brought about on an agreed political and diplomatic level and not through the agency of an organization which is primarily and principally of a scientific and technical nature. Inspection and verification of the actions of countries receiving help from the IAEA could be carried out by a separate organization created specially for the purpose, an organization which would also carry out inspections in other countries. As it is, there is going to be a division between "controlled" and "non-controlled" nations, despite the magnanimous offer of the United States to throw open four of their reactors for inspection.

Of course, any country with a clear conscience will have no qualms about their plant being scrutinized and as the majority of nations represented at the general conference agreed to the proposed safeguards embodying inspection it is hoped that the implementation of the proposals will be accepted in a spirit of good will. With the Agency pledged to maintain technical and commercial secrecy there is nothing for a nation to lose in being inspected. Some of the arguments against the proposals are certainly justifiable; but there has been plenty of time for the Agency to thresh these out and it is regrettable that the Communist countries used the more or less final debate on the regulations as a political platform. It would be a great pity if the International Atomic Energy Agency at this stage of its life should falter and slip into the possibilities of disintegration.

"A lusty child . . ." says Sir Alexander Fleck at Inaugural Dinner of the INSTITUTION of NUCLEAR ENGINEERS

MORE than 200 members and guests attended the inaugural dinner of the Institution of Nuclear Engineers at the Savoy Hotel, London, last month. They were greeted by the President, Sir John M. Duncanson. The distinguished level of top table guests will be seen from the table plan which might have been further enhanced but for a bout of pneumonia which prevented the presence of Lord McGowan and a delayed return from overseas which stopped the Rt. Hon. Peter Thorneycroft, Minister of Aviation, from speaking as was intended.

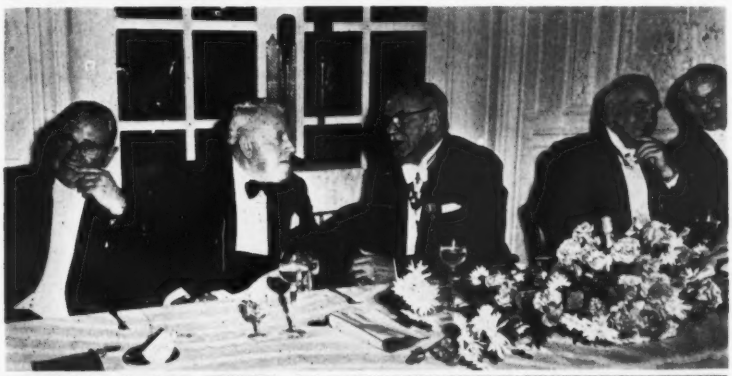
In a preliminary speech the President said he thought that the sincerest things were the simplest said, and he thanked Sir Alexander Fleck for coming along as Guest of Honour, and also the other guests, who had graced the occasion by being present.

" Precisely twenty days from now," Sir John went on, " this Institution will celebrate its first anniversary, and it seems to be destined to increase in strength and significance throughout this twentieth century. Less than a year ago, 500 scientists and engineers from 14 different countries in the world declared their desire, with promises of support, that there should be an Institution of this type devoted exclusively and faithfully to the encouragement of the comprehensive understanding of Nuclear Energy. The knowledge ever increasing must be for the illumination, enrichment and service of all mankind. It is one world and there are no frontiers; the skies encompass everyone from China to Peru, as the saying goes. Ours is a human and a humane purpose and pursuit and our warfare is against shadows and darkness of ignorance; we are the servants of light and not of armies, navies and dynasties.

700 in First Year

" Even in our first year the enrolment in all grades, Full Membership, Associate Membership, Junior Membership and Student Membership, now totals the figure of 700. Of that aggregate, 60 per cent. are people whose homes are in this island and 40 per cent. are from overseas. All Commonwealth countries are represented, and outside of that come ten countries beyond the borders of the Commonwealth.

" Like that of several other Institutions or Institutes, we shall provide an arena in which those studiously and earnestly associated with nuclear development may assemble, discuss, exchange and interchange knowledge and ideas, tell of explorations, experiments, and, as the French say, tour the horizons. This very autumn we are



The first ten photographs show a general view of the banquet hall and the top table guests. The latter have been photographed from right to left and may be identified on the Table A plan. The sixth photograph shows (*right to left*) Mr. Ian Wilson MacDonald, Sir Eric Harrison, Sir John M. Duncanson, President, Sir Alexander Fleck, and Vice-President D. S. Watt

TABLE A.

SIR W. CHRISTIE.

SIR CHARLES F. GOODEVE, O.B.E., D.Sc., F.R.S.

SIR ANDREW MACTAGGART.

MR. M. WHEELER, C.B.E.

SIR ARCHIBALD FORBES, C.B.E.

MR. FREDERICK CARTWRIGHT.

SIR GILBERT RENNIE, C.B.E., K.C.M.G., M.C.

SIR EDWARD J. REID, Bart., O.B.E.

MR. HUGH FRASER, D.L., J.P.

SIR JAMES HUTCHINSON, D.S.O., T.D., J.P.

SIR WILLIAM C. BLACK, C.B.E.

SIR JOSEPH LOCKWOOD.

THE RT. HON. LORD MILLS, P.C.

MR. D. S. WATT, B.Sc.

SIR ALEXANDER FLECK, K.B.E., D.Sc., F.R.S.

SIR JOHN M. DUNCANSON (PRESIDENT).

SIR ERIC HARRISON, K.C.V.O.

MR. IAN W. MACDONALD, M.A., C.A.

MR. HARALD PEAKE, M.A.

SIR JOHN MAXWELL ERSKINE, C.B.E., D.L., J.P.

SIR CHARLES DODDS, M.V.O., D.Sc., M.D., F.R.S.

DR. COPEMAN, O.B.E., J.P., M.A., M.D.

MR. ISAAC WOLFSON.

SIR WILLIAM ROBSON BROWN, M.P.

SIR OWEN WANSBROUGH-JONES, K.B.E., C.B., Ph.D.

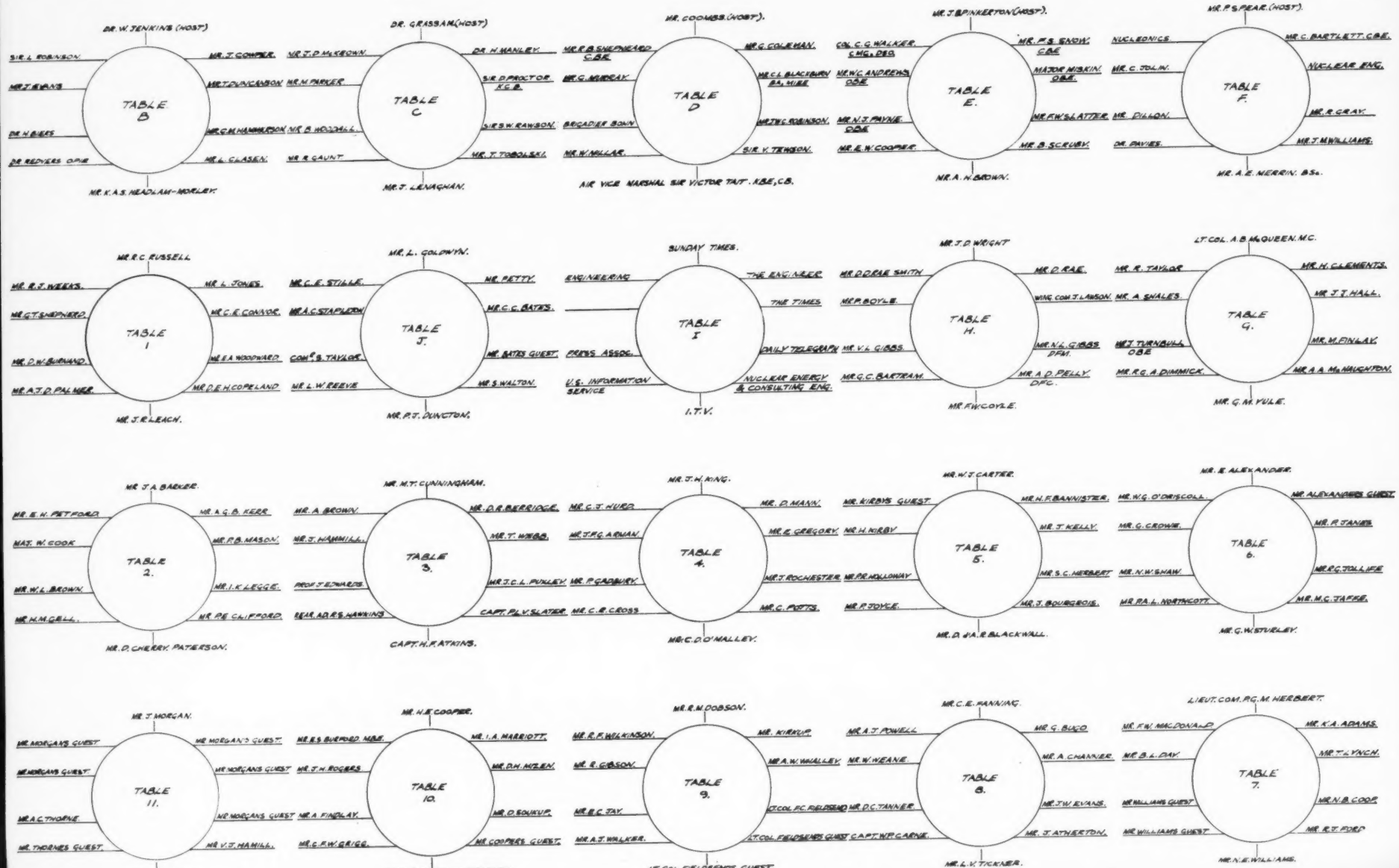
MR. W. K. HUTCHINSON, C.B.E., M.A., B.Sc.

DR. H. J. MANGOLD (FOR GERMAN AMB^{R}).

MR. E. MATHERS.

DR. RUDERNATSCH (FOR AUSTRIAN AMB^{R}).

SIR J. LANG.


DR. W. JENKINS (HOST)
SIR L. ROBINSON.
MR. T. EVANS
DR. H. BILES
DR. REDVERS OPIE
MR. J. COMPER.
MR. T. DUNCANSON.
MR. G.H. HAMMERTON
MR. L. CLASEN.
TABLE B
MR. K.A.S. HEADLAM-MORLEY.
DR. GRASSAM (HOST)
MR. J.D. McSEWAN.
MR. N. PARKER.
MR. B. WOODALL.
MR. R. GAUNT.
DR. H. MANLEY.
SIR D. PROCTOR K.C.B.
SIR S.W. RAWSON.
MR. T. TOBOLSKI.
TABLE C
MR. T. LENAGHAN.
MR. COOMBS (HOST).
MR. R.B. SHEPHEARD C.B.E.
MR. G. MURRAY.
BRIGADIER BONN
MR. W. NELLAR.
MR. G. COLEMAN.
MR. C.L. BLACKBURY BA, MIBE
MR. T.C. ROBINSON.
SIR V. TEWSON.
TABLE D
AIR VICE MARSHAL SIR VICTOR TAIT. A.B.E, C.B.
MR. J.B. PINKERTON (HOST).
COL. C.G. WALKER. C.M.G., D.S.O.
MR. W.G. ANDREWS O.B.E.
MR. N.J. PAYNE. O.B.E.
MR. E.W. COOPER.
MR. P.S. SNOW. C.B.E.
MAJOR MISKIN. O.B.E.
MR. F.W.S. LATTER.
MR. B. SCRUBY.
TABLE E.
MR. A.N. BROWN.
MR. P.S. PEAR. (HOST).
NUCLEONICS
MR. C. TOLLIN.
MR. DILLON.
DR. DAVIES.
MR. C. BARTLETT. C.B.E.
NUCLEAR ENG.
MR. R. GRAY.
MR. T.M. WILLIAMS.
TABLE F.
MR. A.E. MERRIN. B.Sc.
MR. R.C. RUSSELL
MR. R.J. WEEKS.
MR. G.T. SHEPHERD.
MR. D.W. BURNARD.
MR. A.J.D. PALMER.
MR. L. JONES.
MR. C.E. CONNOR.
MR. E.A. WOODWARD.
MR. D.E.H. COPELAND.
TABLE 1
MR. J.R. LEACH.
MR. L. GOLDWYN.
MR. C.E. STILLE.
MR. A.C. STAPLETON
COMR. B. TAYLOR.
MR. L.W. REEVE
MR. PETTY.
MR. C.C. BATES.
MR. BATES GUEST.
MR. S. WALTON.
TABLE J.
MR. P.T. DUNCTON.
SUNDAY TIMES.
ENGINEERING
PRESS ASSOC.
U.S. INFORMATION SERVICE
THE ENGINEER
THE TIMES
DAILY TELEGRAPH
NUCLEAR ENERGY & CONSULTING ENG.
TABLE I
I.T.V.
MR. J.D. WRIGHT
MR. D.D.RAE SMITH
MR. P.P. BOYLE
MR. V.L. GIBBS
MR. G.C. BARTRAM.
MR. D. RAE.
WING COM J. LAWSON.
MR. N.L. GIBBS PFM.
MR. A.D. PELLY DFC.
TABLE H.
MR. F.W. COYLE.
LT. COL. A.B. McQUEEN. M.C.
MR. R. TAYLOR
MR. A. SHALES.
MR. J.T. TURNBULL OBE
MR. R.G.A. DINNICK.
MR. H. CLEMENTS.
MR. J.T. HALL.
MR. W. FINLAY.
MR. A.A. McNAUGHTON.
TABLE G.
MR. G.M. YULE.
MR. J.A. BARKER.
MR. E.W. PETFORD.
MAT. W. COOK
MR. W.L. BROWN.
MR. H.M. GELL.
MR. A.G.B. KERR
MR. R.B. MASON.
MR. I.K. LEGGE.
MR. P.E. CLIFFORD.
TABLE 2.
MR. D. CHERRY. PATERSON.
MR. M.T. CUNNINGHAM.
MR. A. BROWN.
MR. J. HAMMILL.
PROF. T. EDWARDS
DEAR. A.D.R.S. HAWKINS
MR. D.R. BERRIDGE.
MR. T. WEBB.
MR. J.C.L. PURLEY.
CAPT. P.L.V. SLATER.
TABLE 3.
CAPT. H.F. ATKINS.
MR. J.H. KING.
MR. C.J. HURD.
MR. J.F.G. ARMAN.
MR. P. GADBURY.
MR. C.B. CROSS
MR. D. MANN.
MR. E. GREGORY.
MR. J. ROCHESTER.
MR. G. POTTS.
TABLE 4.
MR. C.D. O'MALLEY.
MR. W.J. CARTER.
MR. KIRBYS GUEST.
MR. H. KIRBY
MR. P.R. HOLLOWAY
MR. P. JOYCE.
MR. H.F. BANNISTER.
MR. J. KELLY.
MR. S.C. HERBERT.
MR. J. BOURGEOIS.
TABLE 5.
MR. D. & A.R. BLACKWALL.
MR. E. ALEXANDER.
MR. W.G. O'DRISCOLL
MR. G. CROWE.
MR. N.W. SHAW.
MR. R.A.L. NORTHCOTT.
MR. ALEXANDERS GUEST.
MR. P. JANES.
MR. P.G. TOLLIFE
MR. M.C. JAFFE.
TABLE 6.
MR. G.W. STURLEY.
MR. J. MORGAN.
MR. MORGANS GUEST.
MR. MORGANS GUEST.
MR. MORGANS GUEST.
MR. A.C. THORNE
MR. THORNES GUEST.
MR. MORGANS GUEST
MR. V.J. MAHILL.
TABLE 11.
MR. G.M. HARVEY.
MR. N.E. COOPER.
MR. E.S. BUFFORD M.B.E.
MR. J.H. ROGERS.
MR. A. FINDLAY.
MR. C.F.W. GRIGG.
MR. I.A. MARRIOTT.
MR. D.H. MILLEN.
MR. D. SOUKUP.
MR. COOPERS GUEST.
TABLE 10.
MR. T.O. DUDDALE-BRADLEY.
MR. R.M. DOBSON.
MR. R.F. WILKINSON.
MR. R. GIBSON.
MR. R.C. JAY.
MR. A.J. WALKER.
MR. KIRKUP.
MR. A.W. WHALLEY.
LT COL. P.C. FIELDSEND
LT. COL. FIELDSENDS GUEST
TABLE 9.
LT. COL. FIELDSENDS GUEST.
MR. C.E. RANNIAG.
MR. A.J. POWELL
MR. W. WEANE.
MR. D.C. JANNER.
CAPT. W.P. CARNE.
MR. G. BUCO
MR. A. CHANNER.
MR. J.W. EVANS.
MR. J. ATHERTON.
TABLE 8.
MR. L.V. TICKNER.
LIEUT. COM. P.G.M. HERBERT.
MR. F.W. MACDONALD
MR. B.L. DAY.
MR. WILLIAMS GUEST
MR. WILLIAMS GUEST
MR. K.A. ADAMS.
MR. T.L. LYNCH.
MR. N.B. COOP
MR. R.T. FORD
TABLE 7.
MR. N.E. WILLIAMS.

The first two photographs on this page are of the left-hand end of Table A

starting a series of monthly lectures and are offering prizes for papers submitted by our members. I am very glad to say that the first prize will be of One Hundred Guineas, and there will be other graded awards."

There was good reason to be delighted by the attendance of a large and distinguished company at the dinner. If, as it was hoped, all present attended the dinner at the Tenth Anniversary of the Institution, what marvels of progress might then be accomplished. "I envy our Junior Members and Students," the President added.

Prophecies of Despair

Quoting from a shrewd observation made by "one of high eminence in the sphere of research," Sir John recalled that an engineer had been defined as one who over-estimated what he would accomplish in one year but wildly under-estimated what he would accomplish in the next decade. Touching on the future, we drew comfort from the past. We were inclined in certain moods to forget the strength of the Commonwealth, bound together, as Burke expressed it, by bonds light as air but strong as links of iron. In our life time, many of the developments in coal, steam, steel, electricity and chemicals had had their impetus and origins in Great Britain and the Commonwealth.

Even ardent believers in Britain's powers indulged on occasions in prophecies of despair, which were now amusing. There were examples for pity and laughter. In 1848 Lord Shaftesbury had declared: "Nothing can save the British Empire from shipwreck." In 1849 Disraeli, like Homer, had nodded: "In industry, commerce and agriculture there is no hope." In the early years of the nineteenth century William Wilberforce had lamented: "I dare not marry, the future is so unsettled"; and the celebrated William Pitt asserted: "There is scarcely anything round us but ruin and despair." In 1851 the Duke of Wellington, dying, said: "I thank God I shall be spared from seeing the consummation of ruin that is gathering about us."

Said the President of the Institution of Nuclear Engineers in 1960: "The sheer truth is that we have grown from strength to strength and I have a deep and abiding faith in a people which can prove great in trials and ordeals as it has done from the time of Queen Elizabeth the First to the reign of Elizabeth the Second.

Aware and Alert

"As to the Nuclear Age, and the immense potentialities, I know that the man and woman in the street are fearfully aware and sorrowfully alert. On my journey from Edinburgh the other week I read a newspaper in which was a bold headline, 'Nuclears March on London.' The purpose was to lodge a protest in Whitehall against the atom or hydrogen bomb. I can appreciate the dread but I believe with my whole heart and mind that nuclear energy, rightly harnessed and applied, will prove to be one of the great servants of mankind and will manifest itself in the ease of suffering, the lightening of toil, the implementing of

Table B

Table C

leisure and the enhancement of the standards of living.

"One of the materials on which in our lifetime we have based the waging of war is steel, but I've never heard of a procession to London to petition against the production of it. Steel produced guns, tanks, shells, battleships and was a shield against the despots and despoilers but it is also a vital element in the peace and grace of living and bestows on us ten thousand benefits."

Sir Alexander Reflects

The President concluded: "It is my privilege to ask Sir Alexander Fleck now to address us and also to propose the Toast of the Institution and the Guests. In an assembly such as this, it may seem to be somewhat invidious to single out individuals for emphasis of praise but I should be failing in courtesy and duty if I were not to say how much we admire Sir Alexander and how honoured we are to have Sir Eric Harrison, High Commissioner for Australia, Mr. Ian MacDonald, Lord Mills and the representatives of Their Excellencies the German and Austrian Ambassadors to add distinction to this night."

Sir Alexander Fleck said that the fact that he had been asked to propose the toast to the Institution and its guests would seem to imply that he was not of the Institution, nor one of its guests. "I hope, Sir John, that you don't attribute my presence to my appetite for the meal, for I can assure you that you would be wrong. It is a great pleasure and privilege to be asked to speak at the inaugural dinner of the Institution of Nuclear Engineers, and I would ask your indulgence whilst I explain why to me particularly it is such a great privilege. It is actually 56 years ago this very month, October, 1960, since I first performed technological operations on compounds of uranium, with a view to helping to further the cause of radioactive research. With a little arithmetic you will gather that I could only be about the age of 15 when I did that, so I want you to understand quite clearly that, whatever technological operations I then was called upon to do, I assure you that I didn't understand one little bit of what I was doing.

Soddy and Rutherford

"Actually, I was taking part, however humbly, in a very far-reaching experiment which was to prove that the element radium did grow from the element uranium. A number of years passed and we came to the time when we were very much concerned with radioactive particles, and at this time I hoped and believed I was engaged on the subject with understanding. That was the work which finally ended up in the formulation by Soddy of the Displacement Law and actually brought in the word Isotopes, which is now so much on the mind of all nuclear engineers. All that was done, as I say, somewhere about 1912, at the feet of my master in those times, Mr. Frederick Soddy, the man who, along with that other great genius, Ernest Rutherford, a few years previously had formulated the theory of

Table E

Table G

Table 4

Table 2

atomic disintegration, a theory, formulated as it was in 1903, and has stood so perfectly the test of time."

Sir Alexander went on to say that the point he particularly wanted to make in this gathering of nuclear engineers was that Soddy, so far away as 1906, in a paper which he delivered to the Institution of Electrical Engineers, had a very good idea that some time there would be an energy produced in large quantities and from atomic sources. It was quite clear that an energy would come from these sources, but no one had any conception for a long time of the exact way in which nuclear energy was going to come about. "But in a gathering such as this of engineers, I would like to impress upon you that Soddy, in 1906, had this idea that we were going to get quite a large amount of energy, and just to enforce the point, I will quote from his paper of 1906: 'It is probable that the elements as a class all possess great internal energy...all attempts so far to accelerate the rate at which the store is being naturally evolved have been unsuccessful...let us in imagination overstep this barrier to progress.' These illustrate attempts, very colourful attempts, I think, show something of the genius of the man, who also said: 'We are starting the twentieth century with the prize in full view, with the actual process in full operation under our eyes in the laboratory of Nature and with nothing therefore to be accomplished but the familiar sequence of imitation, improvement and control'."

"A Thorough Believer"

Sir Alexander continued: "I hope you will understand that, with that background and the view I am happy to express in the presence of Lord Mills that energy is the one thing above all that we in this country need at a low price, I am a thorough believer in nuclear engineering, and in all things that contribute to it."

It had not fallen to his lot to be actively and executively concerned in the developments of nuclear engineering, so it would be inappropriate to comment in any detail of the nature and development of nuclear engineering. Over the past few years, views as to nuclear engineering and how successful it would be compared with the traditional forms of energy had waxed and waned. "We should never lose sight of the fact that nuclear energy is here to stay, and here to develop, and the quicker we get on and develop it the better it will be for this country, and the whole of mankind."

Sir Alexander referred to the recent announcement by Sir William Penny about the "pushing aside of the work on the success of ZETA and concentrating on other types of work." This was a valuable formula for the future of our nuclear thinking. It showed that our people were flexible and not hidebound. "They don't, when once they start on a course, pursue it through hell and high water, if they discover a better way of doing things and that, to my mind, is a very good augury for the future of nuclear engineering."

Although he had not been able to take part executively in the early developments of nuclear engineering, he was nonetheless

Table 10

Table 6

Table 1

Table 9

(*Left to right*) **Institution Secretary Mr. J. B. Pinkerton, Vice-President Mr. D. S. Watt, President Sir John M. Duncanson and Major C. L. Miskin, OBE**

interested when it came along and he was asked to take part in the Nuclear Safety Advisory Council Committee. Safety had many functions and many aspects, and this was particularly true when dealing with safety of nuclear matters. There was the safety inside the actual plant, the safety in the neighbourhood, inside the works where the plant is, and the safety of the depot around the works. Another very important aspect that stirred the public mind was the safe disposal of waste.

A Delicate Balance

"So I have a feeling, which I hope you will share with me, that safety, if I may mix my metaphors, is a delicate subject full of high explosives. This makes it a very important affair for an adviser in safety matters. For an adviser to give too much advice can lead to a loss of effectiveness, but if he does not give any advice at all, then he will never be effective. So it is a very delicate balance between the two and that is the kind of work on which I hope to have the support of your Institution in the months to come.

(*Left to right*) **Sir John Maxwell Erskine, CBE, DL, JP, Mr. Ian Wilson MacDonald, MA, CA, and Commander E. A. Woodward**

"Educating the Institution"

"As the President has said, this Institution has not yet completed a full year of its existence, and I think we may say that this dinner is something in the nature of a christening ceremony. Of course, we must acknowledge that with 700 members already it is a very lusty child. Like other children, of course, it will have to be educated, and we hope, Mr. President, that it will be brought up in the ways of wisdom, and acquire wisdom as it comes to maturity, and we hope also that this Institution will, like other children be neither neglected nor restricted, and get a University education so that it will be able to wrestle effectively with all the problems that come upon it."

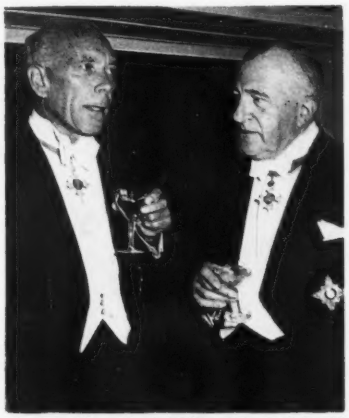
As he had said before, his task was a double one. He had to propose the toast of the Guests, as well as the Institution.

(*Below, left to right*) **Mr. Brian Scruby, Col. C. G. Walker, CMG, DSO, former Secretary of the Association of Consulting Engineers, and Mr. Frederick S. Snow, CBE**

"I think it would be tedious if I were to try to enumerate them all, but I see present many distinguished people, like my friend, Sir Vincent Tewson who, like me, is weighed down with a lot of responsibilities and can therefore be presumed to be growing younger every day, and Sir Gilbert Renny, High Commissioner for Rhodesia and Nyasaland, who seems to accumulate responsibilities every day. So I'm not going to attempt to choose but will confine myself and my remarks to just two, my friend Ian

(*Left to right*) **Mr. G. C. Scott, Mr. E. H. Petford, Mr. D. R. Berridge, Mr. T. B. Webb, Mr. M. T. Cunningham and Mr. A. H. Brown**

MacDonald, and Sir Eric Harrison. Ian MacDonald, of course, has every appearance of being a Highlander, but that isn't so, because he comes from Ayrshire, and so he has all the abundances of being a good Scot, which explains why he has been so successful. We are very proud to have him here. Sir Eric Harrison is also extremely welcome here because, coming as he does from Australia and New South Wales, I am sure he has derived satisfaction from contemplating that one day nuclear energy will largely be the method by which the great open spaces of Australia can be provided with water and so made to increase the population of his country."



The Rt. Hon. Lord Mills, PC (*right*) with Sir Leslie Robinson

(*Left to right*) Mr. G. Coleman, Major C. L. Miskin, OBE, and Mr. W. C. Andrews, OBE

(*Left to right*) Dr. N. S. Grassam, Mr. A. E. Merrin and Mr. J. Williams

Sir Alexander Fleck, KBE, DSc, FRS (*left*) with Sir Vincent Tewson

"Another Scotsman"

In his share of the response, Mr. Ian Wilson MacDonald drew laughter when he said: "I suspect that many of you will be saying 'another Scotsman.' Well, that is quite true, of course. I am another Scotsman. To tell you the truth, if you keep it between these four walls, I am only here in London for a few days to make sure the bank is kept up. It is very much too low for the liking of the Scots.

"It has been of special interest for me to hear Sir Alexander speaking of nuclear energy. During the past few years I have listened to his words of wisdom on quite different topics. On fundamental economics factors to do with the fishing industry, for example, including such problems as can one can cod, and if who, why? I am assured that Sir Alexander is equally versatile whether he is dealing with the principles of nuclear reactions or the emancipation of the herring."

Sir Eric's Dictionary

The Rt. Hon. Sir Eric Harrison, High Commissioner for Australia, was in his usual laughter-raising form. He began by confessing that he was in a dilemma. "When I had to compose myself to respond on behalf of the guests not knowing anything about nuclear energy I resorted to the standard dictionary and I found that the standard dictionary had something to say with regard to 'nuclear.' It said 'pertaining to or depending on a nucleus or nuclei.' Now I ask you! I had no alternative but to pursue this matter further, and I did. I found out that a nucleus was the centre of development or of the central existence, as a nucleus of a political party. That sounded to be like Mr. Cousins at the present moment."

"When I came to nuclei I found that there were biological nuclei, zoological nuclei, botanical nuclei, chemical nuclei, astronomical nuclei and a geological nuclei. So now, perhaps, you begin to understand my dilemma." The High Commissioner went on: "Being an Australian, I cannot, of course, hide my nuclear light under a bushel. We are proud of our progress in the nuclear field. You may well think of us as being a little bit over-cautious, and if that is so I ask you to think of our great many other assets, such as our coal seams 200 ft thick. A slight parody makes an old nursery song still worth singing in Australia, and of course, it is 'Old King Cole was a wealthy Old Soul.'

"Engineers, as I have said before, are essentially practical and go-ahead people. It was Kipling who said that engineers have hairy ears.' Looking down, Sir, I must admit that this professional distinction is, unhappily, all too rare today."

Sir Eric concluded: "My duty is to reply on behalf of the guests. I only hope they know more about this than I do."

With a final word of thanks from the President for the encouraging attendance at the Institution's first dinner, the formal proceedings came to an end, leaving members and guests to circulate, to meet and discuss—and one of their main topics was the second dinner of the Institution of Nuclear Engineers.

RADIATION SAFETY AND CONTROL—IV

NECESSARY RECORDS AND CHECKS

by A. R. Gould
Royal Military College of Science

This series of articles began with a survey of the duties and responsibilities of the health physics officer and before discussing detailed aspects of these duties, an outline of the nature of radiation hazards was given in general terms. This was followed by techniques for the measurement of exposures of personnel and assessment of environmental hazards associated with the two main categories of radiation hazard, *i.e.* " radiation " from sealed sources and " contamination " or " radio-activity " from open sources. Parts four and five review the determination of ingested activity from open sources and similar biological and clinical examinations, discusses the necessary administrative records and concludes with the implementation of radiation hygiene for both sealed and open sources

WITH some γ emitters it is now possible to scan the whole body with a crude form of scintillation spectrometry in a very short time and given even a few minutes more—say a quarter to half an hour/week—it is now possible to carry out a more elaborate determination with both adequate sensitivity and good energy differential resolution. An interesting commercial application of some massive phosphor scintillators is the determination of the proportion of lean meat in a carcase by comparison of the γ activity (due to its natural potassium content) with its total weight, while the same apparatus will also detect the presence of certain fission products.

For many isotopes a regular urine collection and radiological determination can detect significant amounts of excreted activity. Subsequent daily analyses can determine whether the activity so detected is of long-term or short-term origin and whether ingestion continues. Additional chemical precipitations and separations may be necessary or fluorimetric methods may be more convenient (as with uranium for example) for routine daily assays. A recent elegant technique which will undoubtedly develop as a powerful aid to this problem is the application of activation analysis[16] to urine analysis.

Breath analysis has specific application to the classical case of ingested radium-226 where the α emission of radon-222 and its decayed products is detected. Both perspiration and blood have been investigated in certain circumstances, but usually these investigations are associated with emergency conditions.

If routine ingestion assays are made, they must usually be carried out daily in order to be effective in the same way as a film badge is continuously worn to provide continuity in the individual's records of exposure to external radiation.

Blood counts are popularly regarded by many radiation workers as an infallable guide to their own well-being but some authorities now doubt the utility of this simple test in relation to exposure,[17] although they have been established routine for many years amongst hospital physicists[18] and especially valuable indicators of dosage to cyclotron workers[19].

Where any radiation hazard exists, then a system of blood counts should be organized. Even with beta emitters, comparison of groups of workers with different exposures has disclosed significant differences between groups as a whole.

Compare Blood Counts

A comparison should be made between a series of differential blood counts taken before commencing work with radiation and another series three months and six months after exposure to radiation. These should be compared and the differences recorded as increases or decreases in haemoglobin, leucocytes, polymorpho-nuclears, lymphocytes, monocytes and eosinophils.

In any group of average workers, the natural causes of minor blood changes may be expected to give rise to roughly equal numbers of increases and decreases, unless the group is influenced as a whole, by collective diet, epidemic or environmental factors. When different operators have conducted the blood tests, then differences in techniques and the " personal equation " may reflect in changes in group counts.

Two Groups

With small numbers of personnel they may be divided into only two groups according to dosage received above and below a median level. If significant changes are occurring a sensitive indicator is when the group with dosage above the median persistently shows a greater proportion of decreases in haemoglobin together with a greater proportion of increases in monocytes than is exhibited by the group with lesser exposure.

Jasinski and Zlotowsky[20] report such minor changes in these differential blood counts at low levels of exposure to gamma and X-radiation of 4 to 20 mr/day.

This concept of the analysis of collective blood counts of large groups of personnel classified according to degree of exposure to radiation hazard is a very valuable aid to the health physicist in maintaining a close check on the current status of the local hazards. By comparison of the relevant group counts the long term analysis may indicate general trends of group habits or

the pattern of change in different departments should some gross difference occur in local circumstances. Similar comparisons are especially valuable with a new intake of personnel, for comparison of pre-employment counts with those after the initial three months or six months of introduction to radiation work.

Regular Check-Up

Interpretation of *individual* blood tests is a specialist medical problem and particularly with respect to radiation hazards. The individual significance must necessarily remain the responsibility of the medical officer.

The health physics officer must organize suitable routine medical and biochemical tests of blood, urine, breath, skin, eyes etc., with appropriate pathological laboratories. A comprehensive clinical examination should precede the employment[21] of each individual and be supplemented by regular periodic examinations by the medical officer.

Many of the necessary activities of the health physicist are apparently administrative and " organizational " in concept. However, it will soon be found that purely administrative personnel cannot organize a schedule of bio-chemical tests or maintain exposure records in a satisfactory manner. The many different records that must be maintained, demand more than a superficial appreciation of the scientific aspects involved, if technical data is to be analysed and if the necessary factors and correlations are to be handled with reliability, then the records must be kept by carefully trained staff.

The health physics officer must keep a " Radiation and Health Register " in which is recorded all health physics recommendations and action taken. This register should include a digest of the records it is required to certify, such as film records of dosage to personnel, monthly records of stack discharges and liquid effluent disposal checks of safety devices and shielding, examinations of sources and calibration checks of meters and dosimeters. These should be maintained up to-date and made available for examination by authorized inspectors.

Any breach of safety procedure, and any exposure or hazard above permitted or recognized limits, should be reported in a " radiation incident report " to the head of establishment, together with observations of the possible causes and action required to minimize the probability of a recurrence, and should also be recorded in red ink in the appropriate section of the Health Register, in order to draw attention when examined by the inspecting authority.

If a health register is to be maintained by an establishment in which a large number of personnel are exposed and if all the above records are required then the " health register " may actually consist of separate records, log-books, records and diaries which should nevertheless be kept together.

Individual exposure records should be maintained up to date with accumulative totals of all measured and estimated dosages from personal dosimeters and environmental inhalation and ingestion measurements. In addition to the most obvious exposure records, it is important to make a realistic allowance for the degree of personal risk each operator encounters, due to contamination levels (of apparatus, clothing and the work site) and the actual working efficiency of air control, safety shields and operative devices during the periods under review.

Annual Report Vital

The health physics officer must always know the overall picture of radiation hazards on site and an essential aid to a comprehensive assessment is the regular maintenance of many graphical representations of analyses of health-physics determinations for comparisons and cross-checks. Of course one of the most important is the annual register of the total dosage to each individual with weekly entries plus the current total for the previous 13 week period. Further group totals should be kept to indicate the relative status of safety in different operations or departments. These group totals (selected according to local conditions of risk) should be expressed both as an average dose per man and as a total dose to the group irrespective of population.

An important significance of the group's total dose is that it is now realized that genetic damage is cumulative, according to the total dose given by any operation. Hence an operation which may appear to be relatively harmless when expressed in terms of individual dosage to many people, may in fact be considered as more hazardous than one which results in much higher dose-rates to fewer operators if it had a lower overall total dose. This concept of total genetic hazard is even more applicable in comparison of diagnostic techniques especially when evaluating the economic merits of 35 mm film fluoroscopy applied to mass radiography.

Real Hazards

It will now be appreciated that a fully comprehensive health physics organization is required where an appreciable contamination hazard exists. Where there is only a radiation hazard from machines to a small number of personnel the services of a health physics officer are only required in an advisory capacity.

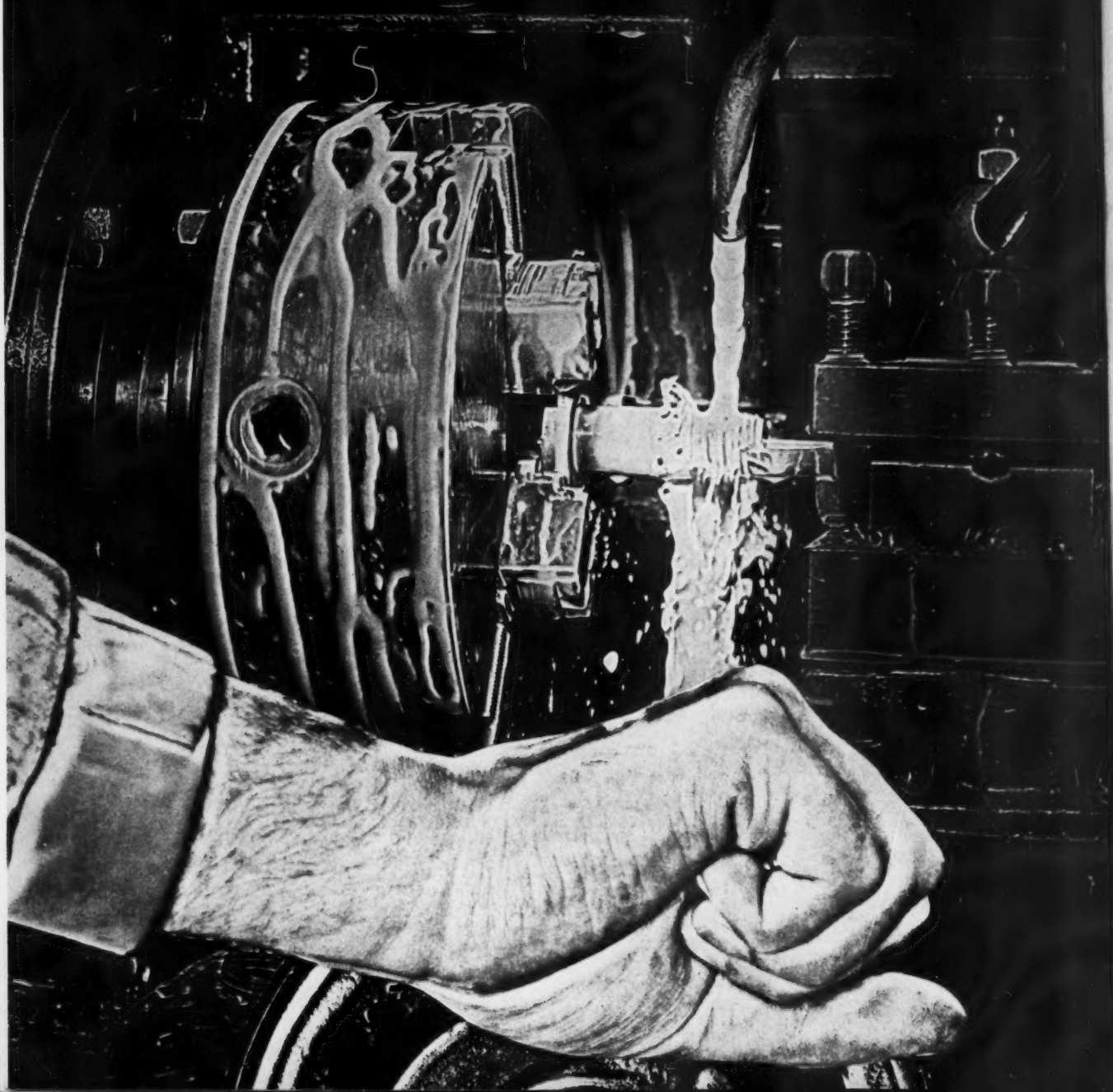
However, all the contamination hazards previously described are very real potential hazards wherever so called " sealed sources " or isotopes are in use. In normal conditions of use these sources present only a " radiation " hazard, but even so, many serious cases of widespread and undetected contamination will continue to occur from sealed sources which are not subjected individually to regular inspection and check. It is quite common for radiographic sources to spread appreciable amounts of contamination around plant and workshops for many months without detection. Frequently, containers rupture due to equipment failures, mishandling, mechanical fatigue and the corrosive effects of industrial or laboratory atmospheres. The consequences of even minute rupture in the container may be so far reaching that considerable effort would be justified to ensure that these hazards are minimized.

Cheap, Simple Detection

Fortunately, it is not necessary to invoke the use of elaborate apparatus to detect contamination before any use is made of a defective source. Without involving any costly or time-consuming techniques, very simple, regular checks for contamination will give confidence to the operators and minimize the possibility of wide-spread contamination.

(*Continued on page 541*)

Greater safety for hands



With new Shell Dromus Oils

Most modern soluble cutting oils contain phenolic compounds used as coupling agents between the oil and the emulsifier, for better blending and easier mixing. These phenolic compounds can cause skin irritation, especially where modern high-speed machines are used and the emulsion can concentrate, through the evaporation of water, above the safety level.

Shell research chemists have been working on this problem, which has been causing some concern to Management. After considerable research, Shell Dromus Oils have been reformulated and these new cutting oils now produce bland emulsions, which considerably reduce the risk of skin trouble to operators.

The real difficulty was to find a new coupling agent to replace the phenolic compounds, and Shell finally used what their chemists know as a higher fatty alcohol complex. This solved one problem, but presented another. The new coupling agent was volatile at the high temperatures normally used in blending processes. Further research found a solution to this problem by designing and installing new plant.

The new Dromus Oils are every bit as efficient as before and cost no more. They put Management in the welcome position of being able to minimise working hazards at no extra cost. And machine men need no longer be so worried about skin troubles.

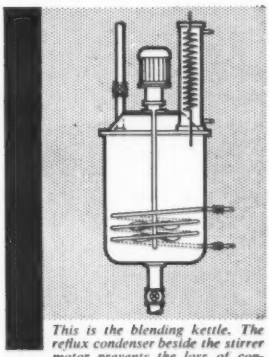
The moral of the story is that Shell research is supremely applicational. The centre at Thornton is always ready to work with even the most specialised sectors of industry to produce the right oil for the job. If you and your organization have any major lubricating problems, it pays to get in touch with your local supplier of Shell Industrial Lubricants.

The Research Story

Shell chemists in the U.K., in Holland and in the U.S.A., prepared and examined hundreds of experimental soluble oils, and established that certain combinations of fatty alcohols could be used in place of phenolic compounds with no loss of efficiency. They set to work to discover the best combination and developed a higher fatty alcohol complex which fitted exactly. Then they realised that to blend this new coupling agent into soluble oils would require special plant and new blending techniques.

Exhaustive testing of blend stability, emulsion stability, anti-corrosion and machining properties led to selection of the most promising blends. A pilot plant was set up to produce batches of these for use in field trials.

This field testing and final development proceeded for two years whilst production plants were erected at points so chosen as to give the most economical and rapid delivery throughout the United Kingdom.



This is the blending kettle. The reflux condenser beside the stirrer motor prevents the loss of constituents volatile at the blending temperature.

NEW SHELL DROMUS SOLUBLE CUTTING OILS

another proof of Shell leadership in lubrication

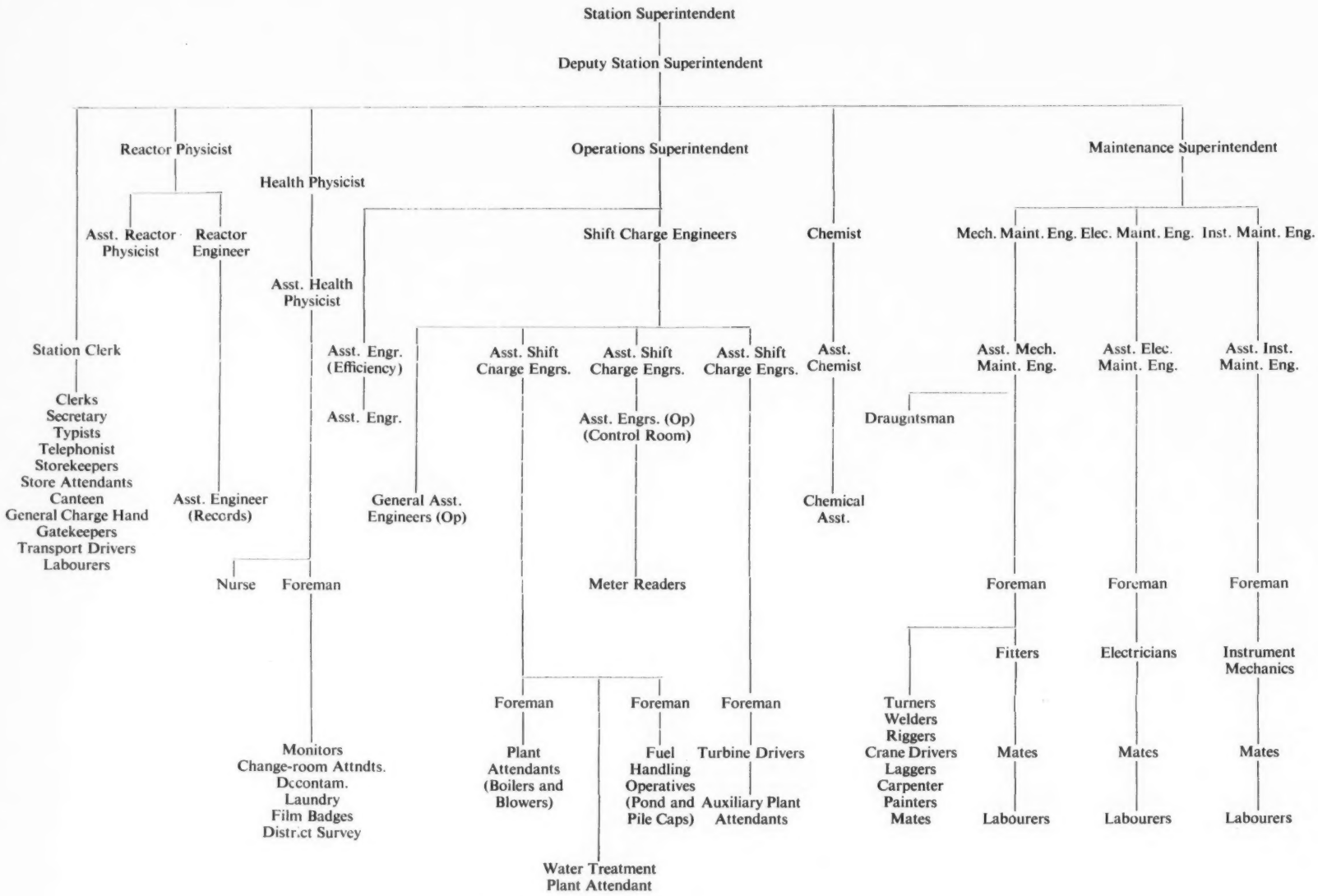


Fig. 1.—Typical Staff Tree for Nuclear Power Station

STAFFING
the Current C.E.G.B. Nuclear Power Stations

by

J. S. Bartlett, AMIMechE, AMIEE

Central Electricity Generating Board

THE recruitment and training of staff to operate the CEGB nuclear power stations now being built have created problems of an extent and nature not previously experienced in the electricity supply industry. At the outset of the civil nuclear programme, people with experience of nuclear generation were obviously unobtainable and it was necessary to look for staff who were experienced in operating some major part of the plant, that is either the operation of nuclear reactors or the operation of the conventional parts of the station. The availability of the former category, however, could only scratch the surface of the problem, and even with only the few early stations in mind, it was decided to turn inevitably, and almost exclusively, towards those who had had experience of operating conventional generating plant.

The problem was thus resolved into one of selecting such staff and then giving them suitable training. They would start with the benefit of being used to an operating philosophy and concepts of safety which had been developed on conventional plant and which could be applied with value to the operation of nuclear generating plant.

Basically the Same

Typical staffing of a nuclear power station is shown in Fig. 1 (*opposite*). It was appreciated in the early days that while much of the organization applicable to conventional plant would be necessary, there would be a need for additional sections. The detailed form might differ from one station to another.

The most noticeable addition to the usual designations is the reactor physicist who, of course, gives advice on all aspects of reactor physics at the station. Then there is the reactor engineer whose time, at least initially, is occupied with the fuel charge/discharge programme. The Health Physics section covers routine and special monitoring of the plant and site, decontamination of tools, plant and equipment, effluent control, the running of the laundry, and is concerned with the continual examination of milk and herbage from the surrounding countryside.

A man per MW

It is perhaps appropriate here to note the comparison between the numbers of technical and manual staff in conventional stations and those in the early nuclear stations. The number of men/MW (sent out) in modern conventional stations varies fairly widely but the average compares roughly with nuclear station staffing. No nuclear station is yet operational but it is envisaged at present that a figure for the early stations would be not much higher than 1 and rather less than this for a station of 500 MW capacity or more. Fig. 2 shows the trend of the percentage of technical staff in all conventional stations. The trend is upwards but the increase has been falling off. The percentage of technical staff in the early nuclear stations is around 16 per cent. compared with the present conventional average of about 13.5 per cent.

Apart from the natural desire of most people to obtain a position which may be regarded as promotion, there are several important factors which have a bearing on an individual's desire to obtain a post in a nuclear power station; some of these are positive, some negative.

First of all there is perhaps an inner feeling of satisfaction, a pride in being something of a pioneer in a new field, one which has not escaped public attention. In addition there is the interest value of being engaged in a new enterprise. This should not be underestimated, even though some might not admit to it. There is also

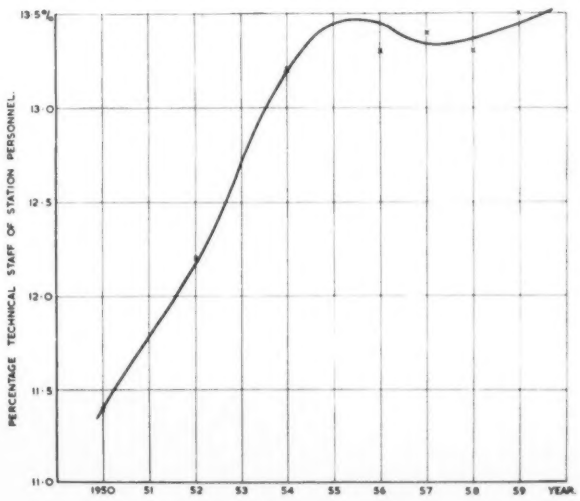


Fig. 2—Growth of technical personnel in conventional power stations expressed as percentage of total staff

The Author

Mr. Bartlett for the past three years has been an engineer in the nuclear operations branch of the CEGB. Previously he was a deputy power station superintendent

some financial incentive by way of higher pay for many of the personnel in the nuclear stations.

On the other hand, however, there is the fact that during any training which may be necessary, a considerable amount of time might have to be spent by the trainee away from his family for a period of up to 12 months or more. This is something which each individual must assess for himself in the light of his own domestic circumstances. This position will eventually be alleviated. There is the further point that for technical, amenity and policy reasons, nuclear stations, at least for the present and near future, are being built in rather sparsely-populated and remote areas. Convenient educational facilities in such an area might not compare favourably with those in a large city and if indeed they should prove to be unacceptable it could be some time before it could be shown that improvements should be made. This again is a matter requiring personal assessment.

Housing a Problem

Also arising from the siting of the station is the question of suitable housing. This is not an entirely new problem as it has sometimes occurred in the case of conventional stations. In a remote area there tends to be a very small turn-over in house property and frequently what is available on the market is not the kind of property sought by the employee. In some cases, however, liaison with the local authorities has taken place at an early stage and as a result rented council property has been made available. Nevertheless some people dislike the idea of living in "megawatt mile," cheek by jowl with their working colleagues.

Creating Amenities

There is also the question of social amenities to consider. These are obviously not of the variety and extent which are available to a town-dweller. But a certain amount of social activity may be promoted by the power station social club and the very nature of the area itself suggests many pursuits particularly when there is the sea or a large estuary in the vicinity. It might be said, therefore, that while social amenities are of a different type from those in more populated areas, and to which the majority will have been accustomed, they are not altogether absent.

These are some of the points which will be considered by a potential recruit to a nuclear station. In general the CEGB has found the response to staff advertisements to be good.

The source of the management, shift and maintenance staff (technical) has been almost entirely conventional power plant personnel. On the other hand, because health and reactor physics are new to the electricity supply industry, specialists in these fields have mostly come from outside the industry.

Preliminary Course

For most technical staff recruits, nuclear training has started with a specially-arranged six-week course of theoretical instruction at a technical college. This was originally organized in conjunction with the Atomic Energy Authority and has included lectures on nuclear, reactor and health physics; chemistry, metallurgy and heat transfer as applied to reactors and reactor materials; nuclear instrumentation and control. A review has been made of the courses from time to time and in conjunction with the colleges changes in content have been made when these have been thought desirable. Latterly there has been rather more emphasis on physics and certain aspects of metallurgy, largely at the expense of instrumentation.

There has then followed a course of similar duration which has involved lectures designed to be complementary to this previous instruction and to highlight it in a practical way. This course has included lectures on the design, commissioning and subsequent operation of UKAEA reactors at Calder, health physics and safety, and other miscellaneous subjects. This has also involved visits to various UKAEA establishments for talks on, demonstrations of, and participation in operational procedures. This course has been undertaken at the Calder Hall Operations School.

The longest part of the training has been a period of attachment at UKAEA plants at Calder Hall or Chapelcross where some practical experience has been obtained in all sections of the plant, with a bias towards that section of particular interest to the individual. The length of this attachment is varied according to the needs of the trainee but in the case of the majority has averaged about four months or so.

The technical staff recruited for the early stations have been able to report to their respective stations at a fairly early stage to assist during construction and this has enabled them to have a generous period of plant familiarization.

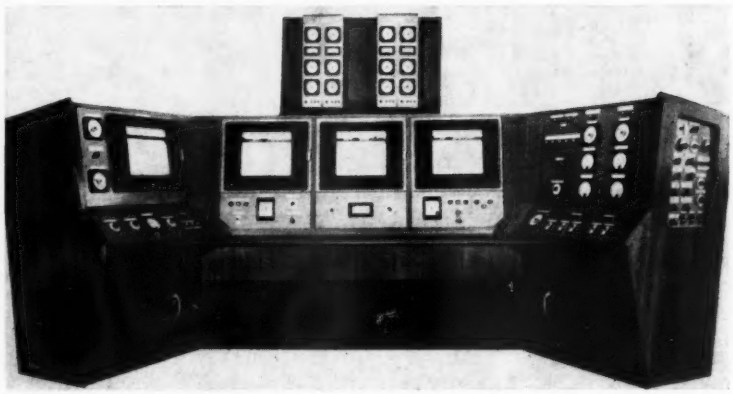


Fig. 3—Desk unit of Elliot reactor simulator

Simulator Training

The CEGB has recently commenced a follow-up two-week course of reactor operation training centred on a simulator. The first week consists of demonstrations on the simulator of both normal and abnormal operation whilst the second week is devoted to individual practice and the preparation of logs and graphs of the operations carried out. A photograph of the simulator desk appears in Fig. 3. On the left-hand and centre panels are to be found the usual reactor controls for a gas-cooled graphite-moderated uranium-fuelled reactor. The right-hand panel contains the instruments and controls

for the gas blowers and for two turbo-generators together with various trip indications. Mounted back on the wall, in the centre, are the boiler panels, the left-hand one giving the readings of temperature, pressure, evaporation and drum water level on any one of five boilers, whilst the other panel gives similar readings on a sixth " fault " boiler. On the side panel on the extreme right can be seen the " fault " controls where either the instructor or the trainee himself can simulate various fault conditions on the reactor or its associated boilers or generators. Automatic features have been deliberately omitted on the grounds that trainees learn more from actual manual operation.

Somewhat Academic

Some of the fault conditions which were specified are somewhat academic since on a real reactor trips would shut down the reactor. Nevertheless it is useful to be able to demonstrate, with the trips on the simulator by-passed, the conditions which would have obtained, and thus a full realization of fault implications may be brought home to the trainee. Although practice may be obtained in normal operating procedures, faults form an important part of the training and among those which may be simulated are the following:

Loss of one gas blower.
Loss of all blowers (either to 10 per cent. speed or zero).
Loss of one or more generators.
Loss of feed water to one boiler (H.P., L.P. or both).
Loss of feed water to all boilers (H.P., L.P., or both).
Breakage of a control rod wire.

The operations can be carried out with various parameters, in particular the graphite temperature coefficient can be set at various values both negative and positive. There is in addition the facility to speed up operation of the simulator from real time to $\times 10$. This is especially valuable when the trainee wishes to study a trend over a lengthy period such as Xenon poisoning effects following load change.

The importance of these faults is to see how they reflect upon reactor conditions and when appropriate the trainee can gain experience of taking corrective action. Since it is also possible to inject positive reactivity, other operations may be simulated such as the removal of absorber and the effects of on-load fuel changing.

The simulator would be available for any " refresher " courses which might be considered desirable at a later date.

Help from Makers

Instruction of the manual staff in health physics matters and in their own particular work will be undertaken largely by the technical staff at their respective sites. Manufacturers are also assisting in this field where new or novel equipment is concerned.

Unlike conventional stations there will be no immediate large pool of experienced operating personnel from which to promote until the nuclear contribution has grown somewhat. For some time it will probably be necessary to continue training courses, but eventually more posts will be filled by normal promotion within the nuclear field.

Additionally it is felt that as nuclear power becomes accepted as part of the normal industrial pattern, a greater emphasis might be laid upon teaching the fundamentals of nuclear techniques in general engineering courses given by technical colleges and universities.

A factor which will have an influence on recruitment in the near future is the impact of the recent Government White Paper on the nuclear power programme. With an immediate target of about one station per year this will obviously slow down the recruitment of new staff and the movement of staff at existing stations. The number of technical operating staff for nuclear stations for some years to come will thus be about 60-70/year. Nevertheless although the numbers will be reduced, training facilities will still be necessary for some time to come. Nuclear power will not be abandoned although the tempo from time to time may change.

Monographs Received

A Summary of Some Methods of Measuring Fallout from Distant Nuclear Test Explosions, by R. N. Crooks, E. M. R. Fisher and C. J. Fishenden. Published by AERE, Harwell. Reference AERE—M 524. Available from H.M. Stationery Office. Price 1*s.* 9*d.*

Liquid Scintillation Counting of Aqueous Samples, by B. A. Loveridge and A. M. Thomas. Published by AERE, Harwell. Reference AERE—R 2942. Available from H.M. Stationery Office. Price 4*s.* 6*d.*

The Use of Helical Spring Balances in Physico-Chemical Research, by R. M. Dell and V. J. Wheeler. Published by AERE, Harwell. Reference AERE—R 3424. Available from H.M. Stationery Office. Price 2*s.* 6*d.*

Photographic Emulsion Dosimetry and the AERE Film Dosimeter, by M. J. Heard, J. E. Cook and P. D. Holt. Published by AERE, Harwell. Reference AERE—R 3300. Available from H.M. Stationery Office. Price 7*s.*

Critical Comments on The Estimation of Radioactive Contamination Based on The Measurement of Total Activity, by G. Herrmann, H. Hauser and H. J. Riedel, translated from the German by F. Hudswell. Published by AERE, Harwell. Reference AERE—Trans 851. Available at Harwell library.

Periodicals held by the Library as at August, 1960. Published by AERE, Harwell. Reference AERE—M 747. Available from H.M. Stationery Office. Price 11*s.*

A Comprehensive Punched-Card System for the Routine Biological Sampling of Personnel, by P. J. Gomm and M. R. Trump Published by AERE, Harwell. Reference AERE—R 3448. Available from H.M. Stationery Office. Price 2*s.* 6*d.*

A Programme for the Evaluation of Resonance Escape Probabilities and Self-Shielding Factors in Hydrogen Moderated Lattices, by Mrs. A. J. Taylor. Published by AERE, Harwell. Reference AERE—R 3364. Available from H.M. Stationery Office. Price 3*s.*

The Oxidation of Uranium Dioxide by Water Vapour Under Reactor Irradiation, by B. R. Harder and R. G. Sowden. Published by AERE, Harwell. Reference AERE—M 725. Available from H.M. Stationery Office. Price 3*s.*

The Use of Submillimetre Waves for Studying High Density Plasma, by S. M. Hamberger. Published by AERE, Harwell. Reference AERE—R 3260. Available from H.M. Stationery Office. Price 6*s.*

Measurement of the Viscosity of Santowax 'R', Para-, Meta- and Ortho-Terphenyl, Diphenyl and Dowtherm 'A,' by R. W. Bowring, G. L. Christie and D. A. Garton. Published by AERE, Harwell. Reference AERE—R 3309. Available from H.M. Stationery Office. Price 8*s.*

Approximate Solution of the One Velocity Neutron Transport Equation in an Infinite Medium, by G. Rowlands. Published by AERE, Harwell. Reference AERE—R 3369. Available from H.M. Stationery Office. Price 4*s.* 6*d.*

A Report on the ZENITH Exponential Experiment, by I. R. Cameron, G. H. Kinchin and J. E. Sanders. Published by AEE, Winfrith. Reference AEEW—R 36. Available from H.M. Stationery Office. Price 7*s.*

Neutron Density Measurements by Autoradiograph of Detector Foils. Translation from the French by D. J. Wilson. Published by AEE, Winfrith. Available at Winfrith library.

Containment Vessels for Belgian Reactors BR II and BR III

Part III

by G. Herzet, P. Laval and G. Martelée
Cockerill-Ougrée

(*Continued from page 473*)

THE following account of the erection of the BR II and BR III containment vessels is divided into three quite distinct sections. The first deals with work undertaken at the factory, comprising the working-up of the materials, and the erection and welding of the main components. The second deals with site work and is distinguished by: 1. The erection and welding of the BR II vessel; and 2. The erection and welding of the BR III vessel. The third covers controls and pressure tests.

With regard to the factory work the main operations in the preparation of the steel plates before despatch to the site were as follows:—

(*a*) Cutting to size and planing the edges;

(*b*) bending to shape: and

(*c*) packing for despatch.

In view of the considerable number of plates to be prepared, and the close tolerances demanded, it was considered economical to make use of an ultra-modern installation for automatic gas-cutting. This installation consists of three portal frames, namely:

(*a*) A central portal supporting two groups of three torches, for the double bevel planing of the long sides of the plate;

(*b*) two abutting portals, each equipped with a group of three torches, for planing each of the two short sides of the plate.

12 Simultaneous Jets

The central portal was started up at the same time as the second abutting portal, then after 3 ft 3 in. of the long sides have been cut, the first portal was set in motion in its turn. From then onwards the three portals work simultaneously, using 12 torch jets.

Bending to shape proper did not set any problems, as the thicknesses of plates did not exceed 1.2 in.

The curved sheets were hot drawn, recalibrated after cooling, sized up and planed after drawing.

The execution of components set some extremely difficult problems, the requisite thicknesses sometimes reaching as much as 6 in. and the materials used consisting in certain instances of plated steel or 18/8 stainless steel (grade 304 ASTM). The weight and size of certain pieces necessitated special solutions. For example there was the reinforcement ring for the vehicle airlock in BR II (Fig. 9). The great size of this reinforcement, 19 ft 8 in. × 16 ft 5 in. × 4 ft 11 in., made it an extremely deformable item, hard to carry out, since the fabrication tolerances are exceedingly low, as the component is welded in an opening made in the steel pressure vessel.

Another example is of an oblique inlet, where close observance of the tolerances imposed necessitated, at the assembly stage, permanent optical control and frequent modifications in the envisaged sequences of welding. In effect, the prolongation of the axis of this inlet situated at a level of +32 ft 9 in. had to finish 62 ft 4 in. lower down in a 4 in. × 6 in. ellipse.

On the BR III the reinforcement for the fuel transfer tank with a total weight of 27 metric tons was a problem. This reinforcement consists of two rings, 3″ and 6″ thick. The lower part has a double curvature, as it is attached to the torispheric base of the structure. The inlet opening is in plated steel; the plating was carried out by depositing weld metal.

The parts were previously machined and shaped, and then assembled on a stand and welded in place with basic electrodes, the preheating of 302° F being maintained throughout the duration of the welding process.

External Erection

For the final design of the BR II pressure vessel, a flatbase version was agreed on, with a cylindrical body and torical dome. To save time, it was decided that erection would be carried from the outside of the pressure vessel, without a central derrick to allow the concreting work to go ahead inside, parallel with the erection of the cylindrical part.

This solution, which at first sight appeared very attractive, proved to be somewhat disappointing, as it provoked a series of snags and delays that were not compensated for by the advantages that were supposed to

Fig. 9—BR II reactor. Reinforcement ring of the vehicle airlock

Fig. 10—Reactor BR II. Erection of the flat base

result from both jobs being carried out simultaneously. Furthermore, it necessitated extremely costly supplementary works and equipment.

As described above, the flat base rests on a slab of concrete about 16 ft 5 in. thick covered by a 1.2 in. layer of " Flint-coat," a material sufficiently plastic to take up certain deformities in the base. After stamping out, sand-blasting and welding the support flats in the shop, the steel plates were placed in position on the site and the whole base was completely assembled before welding.

Factory Machined

The plates of the component rings, factory planed and shaped, were placed in position with the help of an erection derrick situated outside the enclosure. They were brought into their final position with the help of three plate-carrying cars running on the bottom ring.

The plates were fixed together in the lower ring with the help of " Chicago Bridge " type clamps. No pre-assembly took place before final positioning. Each ring is made up of 16 curved plates 20 ft 6 in. × 8 ft 10 in. The adjustment of a ring before welding was not effected until the ring on top had been completely erected, the latter serving as a kind of stiffener.

Welding was not begun until the alignment of the different plates had been checked and the diameters and the horizontality of the projecting joint verified.

After all the vertical joints of a ring had been completely welded the lower projecting joint was welded, which connected it to the part of the structure which had been welded previously.

As regards the welding itself of the joints between the plates of the rings, and of one ring to another, a few words may be said about the very delicate question of the choice of an electrode for site use.

The choice fell on an electrode which proved remarkably suitable for this class of work. The technology of welding, however, was considered to need perfecting.

Each vertical joint was carried out by two welders working simultaneously along it. With all the vertical joints of a ring, and on the periphery with the projecting joints, the principle of symmetry was strictly adhered to.

All making good on the reverse side is carried out by pneumatic chiselling, as the "Arc-Air" process loses most of its advantage from the point of view of speed in view of the grinding down to the bare metal made necessary after gouging out for the input features.

Before the erection of the dome could be tackled, a very awkward problem had to be faced: how to put the top part of the cylindrical section on round, while keeping to the tolerances demanded by the specification, viz ± 1.2 in. on a diameter of 104 ft.

If the average value of the 32 diameters set on the cylindrical part was within tolerances demanded, certain values would exceed the limits imposed.

Taking into consideration the relative thinness of the tank (0.7 in.) the large diameter of 104 ft, the height of the cylindrical part and the absence of a central derrick, it seemed difficult to achieve a precision of 2:1,000 in every respect; and the standards in force, moreover, required for clearly smaller works a tolerance of $\pm\frac{1}{2}$ per cent.

Several methods were tried out, including diametrical cables with adjustable strainers, and external cables worked by a winch, without appreciable results. Finally an independent metal band placed round the steel pressure vessel and resting on brackets solid with the cylindrical body permitted a large proportion of the local deformations to be absorbed by a system of cramps and adjustable screw-jacks.

It is certain that a central mast fitted with an adjustable stay would have greatly facilitated the final task of adjustment before the dome was put on.

It also seems for a structure of this size that a series of intermediate stiffeners—possibly temporary—would have been useful when placing the circular units in their final position.

Dome Construction

The torical dome is made up of six " petals " and a central cap. The different pieces making up the petals were assembled dry in the factory before despatch.

The first two petals were erected with the aid of an off-centre derrick on the inside, the centre being occupied by a concrete block. The plates were fixed in the same way as

Fig. 11—Welding of the joints

the cylinder rings. They were also kept in place by a system of cables, strainers and reversing sheaves fixed to a series of guys welded to the previous ring.

For the following petals, whose inclination to the horizontal increases the nearer it approaches the centre, this system proved impracticable or else too dangerous. To counter these drawbacks, it was decided to erect a complete steel frame inside, capable of sustaining the weight of two successive petals, or about 90 metric tons. A series of adjustable screw-jacks were fixed normal to the various zones, allowing each of the petal plates to be adjusted.

This framework is made up of a central column supporting 32 radial beams which rest at the end of brackets welded to the inner wall of the cylindrical part.

This device allowed the erection of the BR II dome to be completed without trouble.

Although the welding of the two first petals did not set any special problem a new element intervened with the welding of the third petal: extreme cold and snow.

Weather Problem

The problem then occurred of whether to suspend all work till the temperature rose again, or to organize the site to permit the work to continue. In order to reduce bad weather stoppages to a minimum, a series of propane heating batteries were mounted on top of the dome to keep the temperature above zero and to allow welding to continue.

Sheet-metal shelters were fixed to the upper part of the dome to protect the welders from the cold while at work.

The containment vessel for BR III, intended to house a power reactor, is of a smaller size than the one for BR II. It has a diameter of 55 ft 1 in. a total height of 109 ft 11 in. and consists of a torispherical base, a cylindrical body and a hemispherical dome. As the calculated pressure is 42.7 lb/sq.in., the thickness is comparatively greater, most of the plates being 1.12 in. thick.

For safety reasons, it was desired to test all the welds under pressure after the vessel was completed; it is for this reason accordingly that it rests on 12 temporary columns which permit access to all the base welds.

Taught by the experience acquired when building the BR II pressure vessel, we made use of a central derrick, and the work of erection was carried out to completion without difficulty. The base was completely mounted, before welding, on columns previously fixed in the site concrete (Fig. 12).

Site Work Easier

The dry assembly of the entire base that had been carried out in the factory prior to despatch greatly facilitated work on the site, as the main corrections had already been made.

In the cylindrical part the greater rigidity of the plates, the smaller diameter and the increased thickness distinctly helped erection, and it was easy to keep to the required tolerances.

With regard to the dome, the presence of a central derrick did away with most of the troubles encountered in the BR II pressure vessel. In view of the fact, however, that some of the petals were thinner, it was considered advisable, after the dry assemblage, to weld a series of radial stiffeners on to the dome plates.

Most of the reinforcements to which the different airlocks and inlets have to be welded, were in effect, assembled during the winter months.

We are faced with an awkward problem: how to weld pieces of considerable thickness, firmly fixed, at a rather low temperature. In order to solve it with complete certainty, a series of corrugated iron sheds (Fig. 13) was built above the different reinforcements, and, as in the case of the BR II pressure vessel dome, batteries of heaters were kept permanently lit to maintain the temperature on all sides of the welds necessary for carrying out a perfect job.

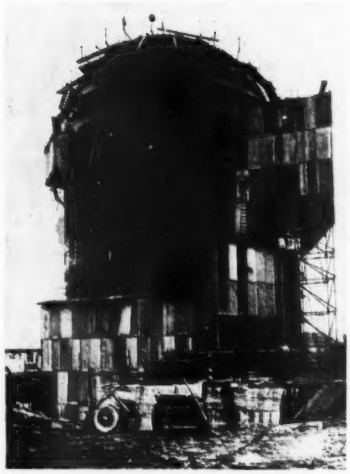


Fig. 13—Corrugated shed built over the BR III during the reinforcements

After rolling, normalizing and straightening, each of the plates was submitted to a series of mechanical tests. In each case, prior samples were taken across at the short and long sides, to be tested for tensile strength, bending, Mesnager impact strength after ageing and Charpy impact strength at 50°F. (10°C.).

In addition all plates were tested by the ultrasonic method before despatch for fabrication. After machining, and before being sent to the site, each plate underwent minute examination, embodying dimensional control, curvature control, and control of the quality and regularity of the chamfering.

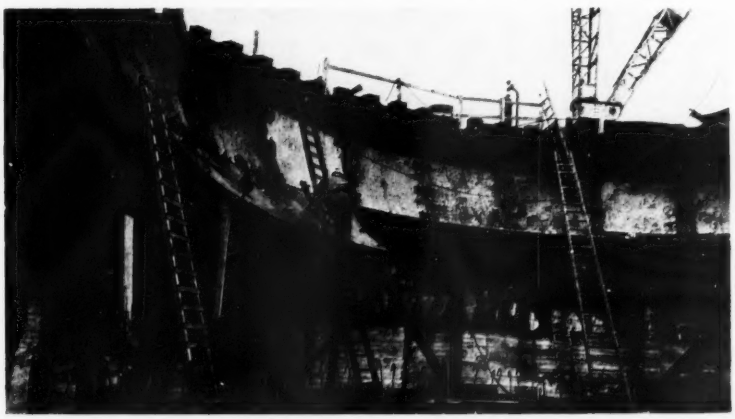


Fig. 12—Erection of the base on columns previously fixed in the concrete site

During erection, all alignments were checked.

As an extra-precaution, it was decided to carry out a complete ultrasonic test of all the welds executed both in the shop and on the site.

The angle welds which could not be radiographed were all subjected to either a magnaflux or dye-check control.

It should also be noted that for certain difficult welds, where the danger of cracking was distinctly higher, a Metalcheck control was effected on the surface and at bevel depth after reaming out the fillet.

On Site Testing

After long discussions, and with the unanimous assent of the building owners, the CEN, its consultants, the BEN, the Société Sofina and Traction et Electricité, the Association Vinçotte and the general contractors, Cockerill-Ougrée, it was decided, when the main work of the steel pressure vessels had been completed and before fitting out the interiors, to proceed to a compressed-air test, The main objectives of this were:—

(1) To make sure, in a absolutely searching and indisputable manner, of the ability of the vessels to resist an internal pressure reasonably higher—from 20 per cent. to 25 per cent.—than the calculated pressure; thus test pressures of 17 and 57 lb/sq.in. respectively, were chosen for the BR II and BR III.

(2) To verify the perfect airtightness of the welds, and to permit the repair of any defects that this examination might possibly reveal before the other works on the inside and outside of the container impeded ready accessibility;

(3) To proceed to tensometric measures with the aim of determining the absence of dangerous stresses and the reasonable agreement of the estimates in the calculations with experimental reality;

(4) To permit the perfecting of the delicate measurements of leakage loading, which can only be properly interpreted at a subsequent test under lower pressure, on completely finished containers, with their inlets equipped with their doors and final coverings.

The practical realization of these tests set a good number of new problems.

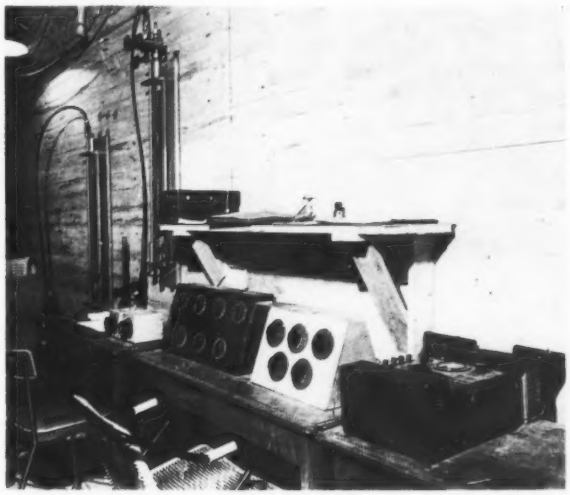


Fig. 14—Instruments used in the tests

It was necessary, *inter alia:*—

1. To ensure airtightness at all the openings that existed at the time of the tests;

2. To supply a form of pressure for the vessel;

3. To provide the different types of control to be put into effect during the tests.

4. To ensure the safety of the personnel in charge of the tests.

All existing openings were sealed by a series of temporary covers. Most of these were welded to ensure perfect airtightness. In the case of inlets fitted with drilled flanges, sealing was effected with the help of bolted covers, airtightness being ensured by a plastic joint gripped between flange and cover.

Safety was ensured by an adjustable release valve directly connected to the airtight container.

Among the different types of control to be carried out on the vessel during the period of the pressure tests may be cited in order of importance acoustic controls, and soapy-water controls.

The acoustic controls proved inoperative. The soapy-water controls, on the other hand, gave complete satisfaction, as the sensitivity of this method is very high and it is relatively easy to carry out.

It was decided to carry out two of them at about $\frac{1}{4}$ of the test pressure; the first when the pressure was being raised, the second when it was being lowered.

After a stiff brushing with a wire brush, the welds were carefully filmed over with soapy water. The first control was carried out immediately afterwards, and a second one five minutes later.

By way of example, the time required for the complete control of the BR II reactor welds was 3 hr, with ten teams of three men. All welds were tested including the temporary ones on the airtight covers.

As the measurement of leakage load required a precise knowledge of the conditions of the compressed air, a series of measuring devices was installed inside the pressure vessel, on the blower circuits and in the immediate vicinity of the tests.

Meters were set up in the cellar that served to shelter the personnel directing the operations (Fig. 14).

At any moment, the necessary information for the normal execution of the tests could be supplied by psychometer, hygrometer, thermistores or manometers.

Similarly, the stresses shown by the different strain gauges could be observed at any moment. A periodic inspection allowed progress to be followed, and in this way it would have been possible to stop or modify the tests in case the readings were alarming.

The different aims set out above were attained in a completely satisfactory manner.

The only leaks registered were localized in places where radiographic control was impossible and ultrasonic testing difficult to interpret. They were, in fact, situated at single-bevel butt welds, mostly temporary ones.

This article is published through the courtesy of Acier-Stahl-Steel. Photographs are by Cockerill-Ougrée.

Development of Materials for Thermionic Generators

by John Coltman

Westinghouse Electric Corporation

Typical cesium metal thermionic converter

THERMIONIC generators produce electrical power by using the electrons emitted from the surface of the material when it is heated to a high temperature. They share with thermoelectric devices the characteristic that the working fluid consists of electrons; they differ in that the heated electrons are emitted into a vacuum rather than into a solid. Because of the high potential difference between the interior and exterior of a solid—a quantity known as "work function"—thermionic generators must operate at high temperatures. Their output voltage is correspondingly higher than thermoelectric converters, ranging from 0.5v to 3v.

Although still in its early stages of development, thermionic generators offer promise as a power source for both military and commercial applications. First, however, materials with a high heat of vaporization combined with a low work function must be found. These materials must be capable of operating for long periods of time at temperatures up to 4,500°F.

At the present time, the thermionic generator is a concept which promises to open up new areas in power generation at high-operating temperature. For military applications where compactness, lightweight, simplicity and high efficiency are required, this device offers promise for practical use.

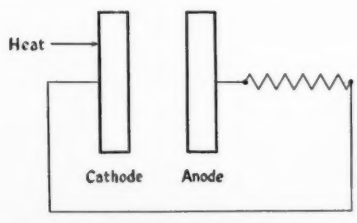


Fig. 1a—Operating principle of a thermionic generator

Mobile Electrons

Consider a plate of conductive material which contains electrons that are free to move and stationary positive charges. This is the cathode. When it is heated, electrons begin to move in a random jostling fashion until a number escape from the surface of the material. Facing the cathode, and separated from it in an evacuated space, is the anode, and an external circuit connected between them as shown in Fig. 1a.

As the cathode is heated, its electron activity increases and electrons escape across the vacuum to the anode. The electrons then flow through the load and through the return circuit to the cathode, thus producing electric power. The concept in this simplified diagram is not new, since emission of electrons from the surface of a heated cathode is a process long used in electron tubes.

A more quantitative picture is offered by the potential diagram which corresponds to the schematic arrangement of the thermionic converter, Fig. 1b.

Here, the potential energy of the electron is plotted at each point in the diagram. The potential inside the cathode material is taken as zero. The electrons inside the metal are normally prevented from escaping by a potential barrier ϕ_C which exists at the surface of the metal, called the work function.

As the electrons become heated, a few of them have sufficient energy to surpass the potential barrier and escape into the space between the cathode and anode. When the electron reaches the anode, it falls down the potential barrier corresponding to the anode work function ϕ_A.

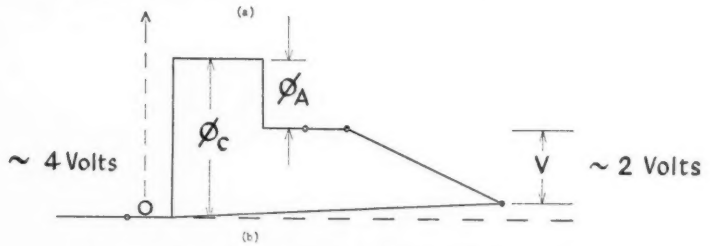


Fig. 1b—Potential energy diagram of electrons in the thermionic system

The energy so released is converted into heat at the anode and is lost in the process. If the anode work function is less than that of the cathode, there remains an amount of energy $\phi_C - \phi_A$ which is available to do useful work in the external circuit, and to supply the electrical losses in the return circuit.

While efficiency is not the only parameter of interest associated with a power converter, it is certainly one of the most important, for it establishes the areas of application. To be of much practical interest, the efficiency of a power converter must be at least 10 per cent. To determine the efficiency of a thermionic converter, the calculated electric power output which can be delivered to a load can be compared with the total heat input. Some of this heat goes into the useful work done; some is transferred to the anode by electron motion; some leaks back through the electrical connection; and most important of all, some is transferred directly to the cold end of the machine by radiation.

Efficiency Calculated

Under certain simplifying assumptions, it is easy to obtain an expression for the efficiency of a thermionic converter. The output power is given by the current times the output voltage:

$$I(\phi_C - \phi_A)$$

The efficiency is this output power divided by the input heat power:

$$\eta = \frac{\text{Output Power}}{\text{Input Heat Power}} = \frac{I(\phi_C - \phi_A)}{\text{Input Heat Power}}$$

The first term in the heat input is that necessary to get the electrons over the cathode work function barrier:

$$\eta = \frac{I(\phi_C - \phi_A)}{I\phi_C}$$

Because this process of raising electrons over the barrier is a thermal one, there is a statistical spread in energy of the electrons emerging. Many of them, in fact, more than just clear the barrier, and, on the average, those that do get out have an excess energy 2kT, which they lose in heat to the anode:

$$\eta = \frac{(I(\phi_C - \phi_A}{I\phi_C + 12kI}$$

Finally, there is the radiation of heat which gives a loss independent of the current represented by R:

$$\eta = \frac{I(\phi_C - \phi_A)}{I\phi_C + 12kT + R}$$

Dividing through by the current the following expression is obtained:

$$\eta = \frac{\phi_C - \phi_A}{\phi_C + 2kT + \frac{R}{I}}$$

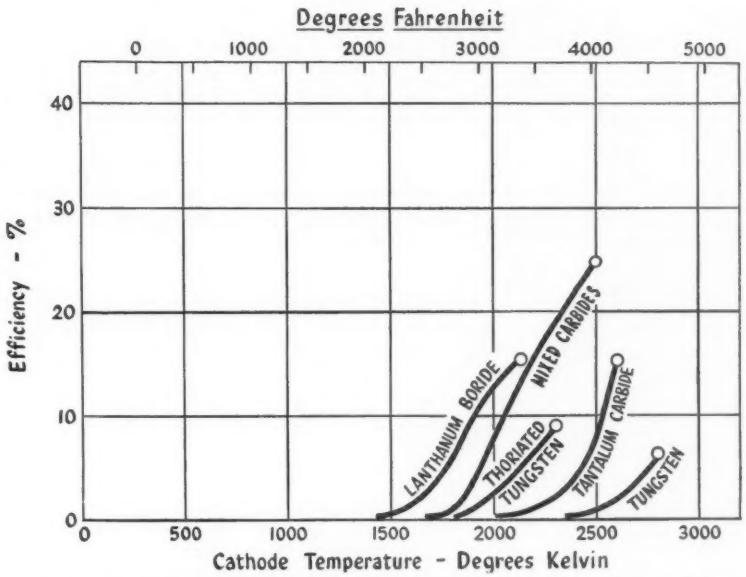


Fig. 2—Plot of efficiency vs. cathode temperature for a number of materials for thermionic generators under investigation at the Westinghouse research laboratories.

It is apparent that when the current is small, the radiation term will outweigh all the others and reduce the efficiency to a very small value. Also, both the current and the radiation power are proportional to the area so that this term is not affected by the size of the device.

Therefore, the essential condition for an efficient thermionic converter can now be stated rather simply—make the current density large.

The current density depends on thermal agitation overcoming the cathode work function; it is a very steep function of the temperature.

While the radiation also increases with the temperature, it does so less rapidly than the current so that a temperature can be found at which R/I will be satisfactorily small. These temperatures turn out to be very high, which is a characteristic of the thermionic converter.

To Reduce Losses

It can be seen from the equation that it is advantageous to use an anode of low work function. Moreover, this anode should have a high reflectivity for infra red radiation, so as to reduce the radiation losses from the cathode.

The efficiency of conversion depends then on such material properties as the work function, electron emission constants and radiant emissivity, and the operating temperature. The operating temperature is, in turn, limited by the melting point or evaporation rate of the cathode. Thus, material properties, both of the anode and cathode, are of importance in deciding whether an efficient arrangement is practical.

It is not possible to describe in a simple fashion those available combinations of material properties which will result in the optimum device. However, Fig. 2 shows some calculated efficiencies for a variety of possible cathode materials as a function of cathode temperature. These calculations, which are meant to be illustrative only, assume an anode reflection such as to give an effective emissivity of 0.5, and an anode work function of 1.8v. Each curve terminates at a point where cathode evaporation becomes high enough to evaporate 1 mm of material from the cathode in 1,000 hr, a condition assumed to represent end of life.

It is noted that each material dictates an operating temperature and that many materials reach excessive evaporation rates before interesting efficiencies can be achieved.

There is another very important factor which determines the current flow in a thermionic converter. This phenomenon is called space charge—the mutual repulsion of electrons. An electron emerging from the cathode

finds itself in the company of a swarm of other electrons, all similarly charged, from which it is repelled. This will drive most of the electrons back into the cathode before they have a chance to reach the anode. One practical way for eliminating space charge consists of introducing heavy positive ions in numbers sufficient to neutralize the charge of the electrons in the space between cathode and anode.

To date, cesium ions appear to be the easiest to produce. The cesium vapour pressure is controlled by using an excess of cesium metal and keeping the coldest place in the vessel at a few hundred °C. Ions may be formed by contact ionization at the hot cathode if its work function is high enough, by impact from the higher energy electrons, or by the temperature of the cesium gas between the plates. Thermionic converters of this type have been called (with some justification) plasma thermocouples. Cesium collected on the anode provides a conveniently low work function.

A typical tube containing cesium metal is shown on page 530. In operation, the tube is enclosed in an oven, and by keeping the device at the appropriate temperature, sufficient cesium vapour is provided to neutralize the space charge. Such a converter is capable of producing appreciable amounts of current, sufficient to run the miniature motor of light flashlight lamps.

The extreme temperatures required for the more efficient thermionic devices militate against their use with fossil fuels. In addition to the difficulty of achieving the required cathode temperature in the face of limited combustion temperatures and convective temperature drops, the permeability of metals to gasses at high temperature poses a severe problem in maintaining for long periods of time a hermetic partition between the vacuum and the combustion spaces. It appears, therefore, that such sources as nuclear fuels and solar radiation are more favourable. Solar sources provide very high temperatures, and also allow the use of a transparent vacuum window through which the radiation may be conducted while the window itself remains cool. Such applications will undoubtedly remain in the highly specialized category.

Possible Applications

Nuclear sources lend themselves to thermionic converters because they can provide temperatures limited only by the structural properties of the materials used. Because the anode of the device can also run at relatively high temperatures without reducing the efficiency, cascading of thermionic units with other lower-temperature converters becomes attractive.

Application of thermionic converters for the commercial generation of power is most favourable when the thermionic element is used as a topping unit for a nuclear steam plant. One is thus able to take advantage of the high temperatures available from the fuel.

A thermionic unit operating with 20 per cent. conversion efficiency and topping a steam unit of 27 per cent. efficiency will provide an overall efficiency of 42 per cent., raising the output of a 50 MW plant to 77 MW. Consideration of the changed capital costs of the steam portion of the plant, and the inclusion of costs for d.c. to a.c. conversion leaves about $190 as a "breakeven" capital cost per electrical kilowatt for thermionic units. Examination of present-day costs for high-power vacuum tubes indicates that it is not unreasonable to achieve such a figure. The life of the thermionic unit is, of course, a critical factor in the economic considerations.

In summary, it seems clear that thermionic conversion offers one possible means of obtaining efficient conversion of heat to electrical power. Whether it becomes competitive with other means will depend largely on the solution of problems concerning the properties of materials. It should be pointed out that, in the past, there has been no particular urge to find or produce materials having the peculiar properties demanded by the thermionic converter. The field is, therefore, one which is largely unexplored and in which one may expect to see advances of considerable magnitude.

Trade Literature

In a brief leaflet issued by Fibrous Glass Products Incorporated, New York, applications and technical details of fibre glass are described and illustrated, with particular reference to package cushioning and vibration isolation.

Crane Packing Ltd., have produced an unusually comprehensive reference book on the use of gland packings. The contents are arranged so that the factors determining the selection of a gland packing are dealt with one by one in logical sequence. Adequate instructions for use are given and an equipment code in the form of a book mark provides an at-a-glance reference to suitable gland packings. Also included are a gland packing selection guide listing about 550 fluids and gases, a maximum and minimum temperature chart, an article on design and performance, notes on effects of temperature and the use of combination assemblies, etc. Comprising 58 pages and well-illustrated the book is obtainable free of charge from the company at Slough, Bucks.

An attractively illustrated booklet, has been published by Head Wrightson Processes Ltd., to advertise water treatment plant, which, as a result of a recent agreement with Belco Industrial Equipment Division Inc., of New Jersey, U.S.A., is to be marketed in this country. A brief description of the processes offered in the field of water demineralization is given and a general guidance to the application of each process, followed by chemical conversion tables.

We have received a copy of "**The Grid**" the lively house magazine of Oldham & Son Ltd. This publication, of particular interest to the company's employees, covers the social activities of the company, and managerial changes, over the past 12 months. A special article on the accounts department at Denton is included, and features on the company's overseas outposts. There is also a feature on the use of "Pg" batteries in coal mines.

Although only a selection of the heat treatment furnaces manufactured by Electric Resistance Furnace Co., Ltd., is shown in their new brochure, the range is impressive. A fairly general description accompanies each photograph of such installations as salt bath furnaces, pit furnaces, atmosphere generators and vacuum furnaces.

In a spiral booklet Newman, Hender & Co., Ltd., describe their range of precision-built, small, forged steel valves, designed for extreme temperatures and pressures. The valves are illustrated throughout the booklet, which also contains air, steam and water flow charts, capacity tables, correction co-efficients and pressure-temperature tables.

General Electric, California, have issued five specification sheets on their equipment for nuclear reactor control. They are supplied in a folder and comprise photographs of the components, relevant data and descriptive information.

WINFRITH A.E.E.

Reactor Research Centre

The reactor group offices at Winfrith

WINFRITH is the second major establishment in the Research Group of the Atomic Energy Authority. Unlike AERE, Harwell, and many other research establishments, it has been planned entirely free from the constraints imposed by previous development of the land. The Development and Engineering Group of the Authority was responsible for the development of the site and for the design of buildings and services to conform to Research Group requirements. The two groups together have given very careful consideration to the layout of the site and design of the buildings, to make sure that the Establishment will fit in with the surrounding landscape.

All the work planned for the Establishment relates directly to nuclear reactors. Some of it is designed to yield information needed by the Authority in their capacity as consultants on the civil power programme and on any nuclear propulsion programme that the Government may adopt; some is to provide basic information needed for the further development of reactor systems that have already been selected as likely candidates for eventual introduction into the Civil Power Programme; and some is in the nature of exploratory work relating to reactor systems and technologies about which more must be known before they can confidently be selected or rejected.

H.Q. for DRAGON

The Establishment is also the headquarters of the international DRAGON project. This has been set up to design, construct and operate an experimental high temperature gas-cooled reactor, in order to obtain experimental proof of the feasibility of some of the novel features which this type of reactor employs. The experimental reactor will employ graphite as the moderator and helium as the coolant, while the fuel is to be a mixture of uranium and thorium in graphite.

The DRAGON project is sponsored by the European Nuclear Energy Agency of the Organization for European Economic Co-operation (OEEC) and the participants are: Austria, Denmark, Euratom, Norway, Sweden, Switzerland and the United Kingdom.

Rapid Progress

The project has advanced very rapidly since its inception early in 1959 and the experimental reactor is already under construction near the west entrance to the Establishment. The project is under the general direction of a board of management, comprising representatives of all the signatories and ENEA. The chief executive of the project, Mr. Rennie, acting in consultation with a general purposes committee of specialists from participating countries, is responsible to the board for the technical and administrative conduct of the work. The Authority acts as the legal agent of the project and provides a number of supporting services for it.

Some research and development is also undertaken at this Establishment by the Authority under contract to the project. An example is the work being carried out with the zero energy reactor ZENITH. This reactor went critical on December 19th, 1959; its initial programme of work is directed towards establishing in detail the design of the core of the reactor experiment which is now being built.

The Authority work in the Establishment is concerned primarily with those factors which determine how reactors may be maintained critical so that they can generate heat, how the heat generated may be removed in a form suitable for conversion into power, and how the reactor may be controlled safely. The information coming forward from this work must be integrated (and, in many cases, reconciled) and this requires the employment of a group of engineers and physicists to do technical assessment work. Such work is also of importance in helping to define the profitable areas for future work.

Inter-A.E.A. Links

There are, of course, very close links between Winfrith and other establishments in the Research Group, especially Harwell where the nuclear physics and materials research is complementary, and also between Winfrith and the other groups of the Authority, in particular the Design and Engineering Group.

Work at Winfrith is broadly organized on a functional rather than on a project basis. By this it is meant that it is more convenient to define the use of equipment or the responsibilities of groups of staff as being for example in the area of reactor physics, or reactor control and instrumentation, rather than to

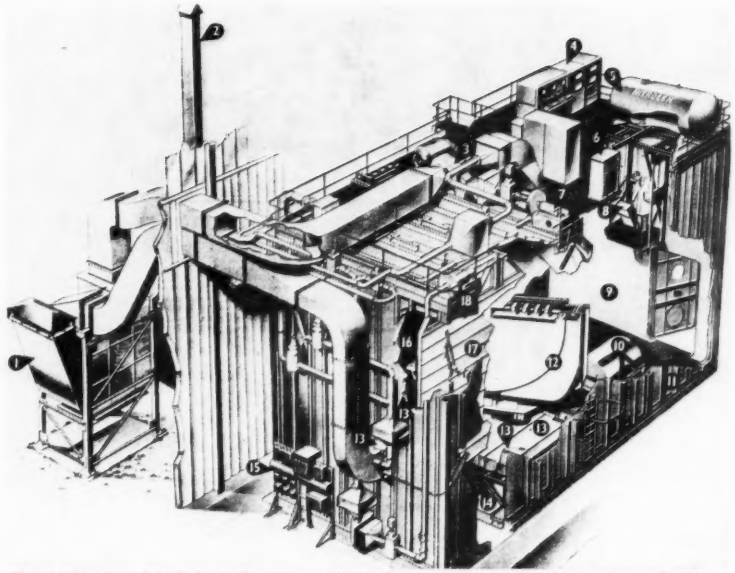
talk about them in terms of particular reactor systems. This is not to say that most of the work being done at any given time cannot be identified as being directly related to a particular reactor concept. Indeed the reverse is normally true. But organization on a functional basis recognises that the special equipment and the staff who are specialists in particular fields may, over a period, be engaged on work which is applicable to more than one reactor system.

As would be expected on a site which is still being developed, the degree to which each class of work has already been built up differs, depending on many factors, such as the priority given to the erection of buildings, the availability of equipment, etc.

Exterior of SCORPIO I

In one building reactor physics work in connection with the Magnox and AGR types of reactors is being undertaken. A number of experimental assemblies supplied with neutrons from external sources are being used for the detailed study of the physics of such systems in a collaborative programme of work undertaken, in association with the Authority, by the industrial consortia which are building the nuclear power stations. This joint programme is known as the British Industries Collaborative Experimental Programme (BICEP).

In addition, the effects which are likely to arise from the continued operation of such reactors for long periods of time when the composition of the fuel changes owing to the burning away of uranium-235 and the formation of plutonium are being studied. Two special pieces of



To predict the critical sizes of power reactors after various periods of operation, a facility has been built at Winfrith in which exponential reactor assemblies containing both uranium and plutonium can be heated up to temperatures of 400°C. Measurements will be made on the assemblies in which lattice geometry, proportion of plutonium to uranium and temperatures can be varied under closely controlled conditions. The main components of this facility, known as SCORPIO I, are shown here. They are: 1 Heat exchanger; 2 Exhaust chimney; 3 Stack cooling blower; 4 Control console; 5 Nitrogen reservoir; 6 Alpha monitors; 7 Differential pressure blower; 8 Pre-heat oven; 9 Personnel chamber and door; 10 Source flask; 11 Alpha containment; 12 Main and circular doors; 13 Heat insulation; 14 Graphite plinth; 15 Main switch board; 16 Graphite stack; 17 Electric heater mats; and 18 Personnel chamber blower

equipment have been built—SCORPIO I and II—for the study of assemblies containing plutonium as well as uranium in the fuel. These assemblies can be heated to 400°C. and the equipment is contained within a steel shell to prevent the release of plutonium to the atmosphere in the unlikely event of a failure of a fuel element can.

Graphite block being placed in the cooling chamber of SCORPIO II, a facility similar in principle and purpose to SCORPIO I but designed to take sub-critical assemblies

In another building sub-critical assembly, HELEN, has been built to enable a study to be made of the reactor physics of systems moderated by light water, or by organic liquids, and with fuels having some enrichment with either U-235 or plutonium.

A reactor NESTOR is being built in building 20A, to provide neutron beams for use with further sub-critical experiments.

Harwell Plant Used

Another method by which reactor physics information is collected, using only small quantities of the material of interest, is by what is known as the oscillator technique. Here the specimen is moved in and out of a reactor and the effect of the specimen on the reactor power measured. The zero energy reactor NERO which has been moved from Harwell will be used in this way for measurements at room temperature. In the more

advanced designs of reactors information over a considerable temperature range and with widely differing neutron energy distributions is required. To make these measurements Winfrith engineers have designed, in collaboration with industry, a special zero energy reactor, called HECTOR.

Sub-Critical Units

Work with sub-critical assemblies and with small samples of material is not able to provide all the physics information required when designing power reactors. To study kinetic and control problems zero energy reactors are often also required. The Establishment is being equipped with three such reactors. One is ZENITH, already mentioned, and another, DIMPLE, a zero energy reactor which is to be moved from Harwell to Winfrith in the early part of 1961. This reactor will be suitable for basic studies using liquid moderators, which might be heavy water, light water, or an organic liquid.

The third reactor in this class to be built at Winfrith is ZEBRA which is for the study of the physics of possible core configurations for power reactors of the fast breeder type.

The preparation of the special fuel samples which are required for these physics studies is an important supporting feature to the physics programme. A small laboratory in which some of these specimens can be manufactured is being established and it will be equipped to deal with plutonium, U-233, U-235, and other special materials.

The basic engineering technology work which is starting at Winfrith covers a wide field concerned with the flow of fluids used to remove heat, and with associated phenomena. Although there is nothing novel about the use of fluids to transport heat, the reactor designer frequently requires information that has not so far been needed for conventional engineering purposes. The work carried out is primarily experimental and much of it is done by pumping the fluids round closed circuits (known as loops) in which electrical heaters are used to simulate the fuel elements of a reactor.

Stabilities Studied

Other engineering problems are also studied. For example work is being carried out on the mechanical stability of fuel element sheaths. The sheath or can of a fuel element must be as thin as possible for good neutron economy, and it must also be mechanically stable under the operating conditions. Special rigs are used to study the effects of pressure and temperature on the stability of thin metallic cans.

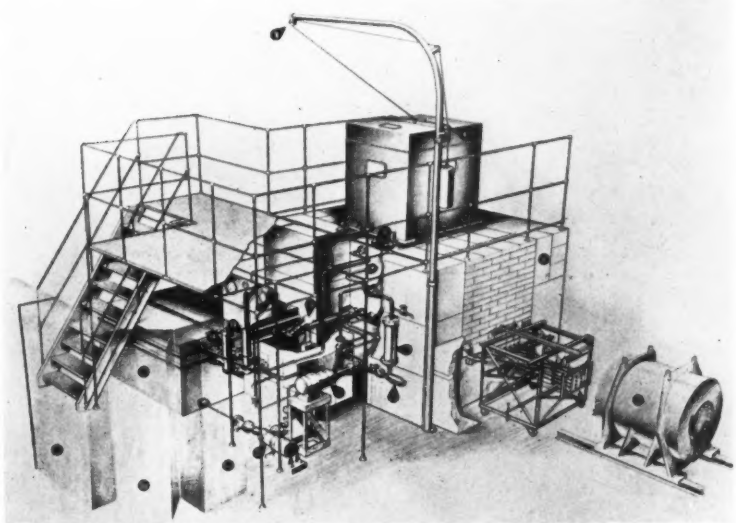
Assembly for obtaining information on the effect of local thermal perturbations on neutrons. Tubes of beryllium and graphite inserted in a large graphite block are electrically heated and the neutron diffusion in them measured, neutrons being supplied from antimony-beryllium sources

As the design of reactors progresses, they are likely to operate at higher temperatures and higher ratings than the present reactors and new fuels such as plutonium, thorium and U-233, may be used. As a result, the operating characteristics may be quite different and may vary more rapidly during the lifetime of the reactor. It is necessary to develop new instruments for detecting and controlling fluctuations in the power level of these reactors and to formulate in advance the principles governing suitable overall designs of control systems.

Support Sections

The scientific and engineering teams are supported by design, manufacturing and operations staff and by special technical services such as computation, chemical analysis, process control and radioactive waste disposal. In this connection mention should be made of the pipeline for the discharge of active and inactive effluent which stretches for 4½ miles overland to Arish Mell, and thence for 2 miles out to sea. Radiation monitoring is carried out to safeguard against exposure to radiation and surveys are made of the area surrounding the site. The health of the Establishment is looked after by the medical staff. In addition there are the site and administrative services normally associated with any research and development establishment.

This article is based on a talk given by Mr. D. W. Fry, director to the Establishment, during a recent open day.



HELEN—a sub-critical liquid moderated assembly for carrying out studies on liquid moderated systems using plutonium fuels. The assembly utilizes plutonium-aluminium alloy plates suspended in the chosen moderator. A neutron source is mounted beneath the tank and the neutron flux obtained is automatically measured at a number of predetermined positions in the assembly. Among the main components are: 1 Control panel; 2 Dump tank; 3 Jib for concentrator; 4 Concentrator; 5 Connections to plutonium monitor; 6 Concrete shielding; 7 Ion exchange column; 8 Flexible source loading tubes; 9 Transport flask; 10 Ion exchange pump; 11 Draining pump; 12 Filling pump; 13 Plutonium monitor; 14 Filters; and 15 Dump valve

'NUCLEARIST' writes . . .

SCIENCE fiction seldom finds its way to my bookshelves, but recently I read "Andromeda" by the Soviet writer Ivan Yefremov. I found it less a work of fiction than most railway timetables, and it contained much food for thought. It deals with an age when space travel is commonplace and atomic energy no longer a novelty. Ion engines and "anameson" fuel are used for interplanetary flights. By contrast with the Age of Disunity (our present era!) most people are scientists. This state of affairs should seem less improbable to Russians than to ourselves, since the U.S.S.R. produces a greater proportion of trained technologists than we do.

Only recently, the Science Masters' Association published the results of a survey which indicated that far too few sixth form girls are being taught science. This means a shortage of science mistresses, and so a vicious circle is set up. I find this reprehensible and incomprehensible state of affairs hardly compatible with the status of an advanced nation.

Across the Channel, Utopia is just as far away. The French, realists in many affairs in addition to those of the heart, feel that nuclear weapons potential must be increased. So they are building at La Hague, near Cherbourg, a second plutonium factory to supplement the output of Marcoule. Success in the Sahara tests has obviously whetted an appetite.

* * *

Second thoughts are becoming a habit with the UKAEA. Early opinions about an approaching fossil fuel depletion have been succeeded by improved economy in conventional power stations, and a cutting back of the nuclear power programme. The Intermediate Current Stability Experiment, for the study of the stability of a toroidal sheath of hot ionized gas carrying a large current and subjected to a magnetic field, is now to be abandoned in favour of a broadening of the thermonuclear fusion programme with several smaller experiments, better diagnostic measurements, and improved techniques for high temperature plasma production. It may seem at first sight that the nuclear powers-that-be are ditherers. Yet it is surely preferable to change horses in midstream than to wear out a steed before reaching the further bank. Only time will tell what proportion of British hunches in the nuclear field will pay off as well as the Calder Hall one did.

* * *

The discovery, many years ago, that the atoms in a solid are wonderfully lined up in an orderly fashion in lattice positions came as a delightful reminder that Nature tries to be tidy. Yet Nature, always assumed to be feminine, can be whimsical and light of fancy, and very often forgets her tidy habits, placing atoms in incorrect places in the solid lattice. To this fact we owe many of the phenomena connected with crystal growth, isomorphous replacement, complexities of natural minerals, ferrites and other semiconductors, scintillation counters and phosphorescent materials, and even Wigner stored energy in graphite and the Windscale disaster. Although much is already known of solid physics, there is far more yet to discover. Here, then, is the justification for the newly-established Solid State Physics Division of the AERE, Harwell. The present head of the Division of Theoretical Physics, Dr. W. M. Lomer, will lead the work of the new section, which will deal not with special facets of reactor technology but with the formation and nature of crystal defects, magnetic metals and alloys, and crystal physics in which use will be made of extracted neutron beams from Harwell reactors.

* * *

At the General Conference of the International Atomic Energy Agency in Vienna, although the conduct of the proceedings was in keeping with the scientific tradition, the world political situation was reflected in some bitter invective directed against the work of the Agency, and quite worthy of politicians. Several speakers, including the president, Professor Nadjakov, and Mr. Cole of the U.S.A. considered that progress had been relatively successful now that the initial organizational period was over. The highlights of the Agency's past work, we might say, included applications of isotopes in many fields, the collection and dissemination of information, nine conferences attracting 2,000 scientists from 41 countries, exchange and training of experts, the standardization of isotope transport regulations, 31 scientific reports, and 400 fellowships to 31 countries. Nevertheless, there was also much criticism.

Speakers bitterly attacked the continued use of fissile materials for military purposes. Professor Emelyanov, among others, accused the Agency of failing to function as a broker in assisting the smaller member nations to benefit from atomic energy. There was widespread dissatisfaction with the safeguards placed upon the issue of uranium. These safeguards, it was felt, were too prohibitive, smacked of political discrimination, failed to limit the preparation of nuclear weapons, were to blams for delays in making reactors economically competitive as power sources, and, in general, fell short of every one of the desiderata. They should be replaced by a system which could at the same time be concrete and restrictive, although not prejudicing the sovereignty, independence or security of any nation.

There was also criticism of the American bilateral agreements, more than suggestions being made that the U.S.A. was trying to gain control over too many countries. Many felt, too, that the problems of waste disposal should be tackled as an urgent matter and with greater vigour. The cost of disposal of highly active wastes in the U.S.A. were $1-3/gal, and this threatened the future of economic atomic power. Although the ejection of wastes into space in rockets would be both prohibitively expensive and very hazardous until launching could be made 100 per cent. certain, the use of salt mines and dry oil wells offered some hope for the future.

Nuclear energy is not likely to be free from political implications for a long time to come. It would be criminal, however, to allow politics to shadow the deliberations of the IAEA so that its objectives and aspirations became thwarted. This Agency was too well-conceived to suffer strangulation at such a tender age. Unhappily, the signs at the moment are that this is what is happening. Only a grim determination on the part of delegates can save the situation, and they must be held together as a united body of scientists.

PEOPLE

Dr .W. C. Marshall

Dr. W. M. Lomer

Mr. A. P. Taber

The Atomic Energy Authority have formed a new division at Harwell. Called the Solid State Physics Division it will carry out basic research leading to greater knowledge and understanding of the structure and behaviour of solids. Head of the division will be **DR. W. M. LOMER,** BA, MSc, PhD, at present head of the theoretical physics division. He will be succeeded in this position by **DR. W. C. MARSHALL,** BSc, PhD. Born in 1926, Dr. Lomer received his university education at Exeter and Cambridge. He joined Harwell in 1952 as leader of the solid state theory group of the theoretical physics division. He was appointed divisional head in 1958. Dr. Marshall, a Birmingham graduate, joined Harwell in 1954 and was a scientific officer in the theoretical physics division. Three years later, on special leave, he went to the California University laboratories at Berkeley and then to Harvard as a research physicist. Last year back at Harwell he took over Dr. Lomer's former position as leader of the solid state theory group.

A new research laboratory is being established in the United Kingdom to undertake research in the field of chemistry, physics and electronics as an overseas arm of the research and development division of American Machine and Foundry Co. This project is being organized by **MR. J. WILSON,** CBE, MC, MSc, and by **DR. A. D. BOOTH,** DSc, PhD, under the general direction of Mr. Hamilton Herman, vice-president and director of research and development for the parent company. Mr. Wilson was at one time manager of the Triplex Safety Glass Co.'s research laboratory. He built up the British Rubber Producers' Research Association, an organization controlled by the Colonial Office. From 1947 to 1957 he built up the British Rayon Research Association under the Department of Scientific and Industrial Research. Dr. Booth is scientific adviser to AMF. In 1937 he took a first class honours in physics at Leeds University and in 1940 won a scholarship to Birmingham University to be trained as an X-ray crystallographer. He then worked for the British Rubber Producers' Research Association and in 1945 proceeded to U.S.A. to work for the Bureau of Standards, Washington, D.C. He is at present head of the computing department at London University.

Appointed assistant managing director of Associated Electrical Industries (Woolwich) Ltd., is **MR. W. A. ANKERSON,** BSc(Eng.), AMIEE, formerly general manager of AEI Home District Offices and also a director of Associated Electrical Industries Overseas Ltd. A college apprentice with Metropolitan-Vickers in 1932, he has been with M-V and AEI since.

ALDEN P. TABER has been elected a vice-president of the American Babcock & Wilcox Co., and placed in charge of the research and development division. Since joining the company in June, 1959, Mr. Taber has been a member of the president's staff, co-ordinating and directing research and development activities. In his new position, Mr. Taber will be in charge of all research and development work of the company. He will also be responsible for co-ordinating this work among all B. & W. divisions and subsidiaries, and for developing plans for R. & D. projects for the company as a whole. **MR. PAUL R. GROSSMAN** will continue as director of the Research Centre. Before joining B. & W. Mr. Taber served on the faculty of Syracuse University as professor of metallurgical engineering. Born in 1907 he attended Indiana University, was graduated from West Point in 1930, and was awarded a Master's degree in mechanical engineering by Massachusetts Institute of Technology in 1948. During his career in the U.S. Army, from which he retired with the rank of Brigadier-General in 1957, he held many technical-administrative positions involving production and research including service as deputy commanding general of the Aberdeen Proving Ground and as commanding officer of the Watertown Arsenal.

MR. GEORGE A. SMITH has been appointed commercial executive of the electronic and equipment group of the Plessey Co., Ltd. This group includes the telecommunications, electronics and the domestic equipment divisions and Hagan Controls Ltd., with a total pay-roll of over 4,000 people. In this appointment Mr. Smith will be responsible for the co-ordination of the four sales organizations within the group. He was until recently general manager of the telecommunications division and prior to that was with Plessey International Ltd., responsible for overseas sales of electronic equipment. Before joining Plessey in 1957, Mr. Smith was for ten years with the telecommunications division of Pye Ltd.

The Ellis Medal for Works Management awarded by the Institution of Works Managers has been won in the first year since its inception by **MR. W. HUDDLESTON,** on the staff of the UKAEA factory at Springfields, near Warrington, Lancs. The medal, which is to be awarded annually to the most outstanding student taking the Institution's two-year training course in works management, commemorates the work of John Milton Ellis who did much to initiate and develop training in industrial management. Mr. Huddleston, who was educated at Barrow County School and Durham University has been working with the Atomic Energy Authority since 1953. In 1957 he was appointed a shop manager and it was about this time that he decided to take the Institution of Works Managers' training course. His progress in this course and the results of his examinations received the highest commendation from the examining body.

MR. PHILIP R. KEEP has been appointed manager of applications engineering at Atomics International, a division of North American Aviation, Inc., it was announced recently. He replaces **DR. ROBERT L. LOFTNESS,** who has been appointed commercial director of Dynatom, the company's new French affiliate in Paris. Mr. Keep joined Atomics International in 1956 as an applications engineer in the technical sales department. He formerly was associated with the Worthington Corporation, Harrison, N.J., as an applications and sales engineer in the foreign division. He was educated at the Northeastern University, Boston, the Harvard Graduate School of Engineering and the California Institute of Technology. A naval officer during the war, he served in Brazil, Panama and Washington, D.C. with the engineering division of the Navy's Bureau of Aeronautics.

The board of directors of Vickers Research Ltd., has been reconstituted. It now consists of **MR. A. H. HIRD,** ACGI, BSc, MIMechE (chairman), **DR. C. F. BAREFORD,** MSc. (managing director), **MR. W. D. OPHER,** MIMechE, **MR. W. D. PUGH, MR. L. REDSHAW,** MEng, MRINA, MInstW, **MR. S. P. WOODLEY,** MBE, MIProdE, and **MR. P. R. H. YAPP.** The secretary is **MR. A. D. READ,** ACA. Transfer of the company's research establishment to Sunninghill, near Ascot, Berkshire, has now been completed. Research at present being conducted on behalf of the Vickers Group includes a variety of projects in the spheres of nuclear, medical, chemical and electrical engineering.

U.S. CRITICIZED OVER N-ROCKETRY

by Peter Lewis, Our Parliamentary Correspondent

EARLY September the American Congress, the 86th to be precise, adjourned and went off to do battle in the election campaigns which culminate on November 8th. The Democrats have pledged that they will encourage the construction of giant regional power systems including nuclear power, and while there appears to be little controversy between the parties over nuclear matters there has been some confusion of a non-partisan nature over the use of nuclear energy for rocket propulsion.

Senator Clinton Anderson, a Democrat from New Mexico and chairman of the Joint Committee on Atomic Energy, made a strong plea for what amounted to a "rethink" on the programme for nuclear power for space exploration. Senator Anderson thought that the United States had the opportunity to create a climate of world goodwill through leadership in peaceful space exploration, at the same time he charged that there was no national policy for the utilization of nuclear rockets; while there was some research, it was reluctantly and partially funded, but there was no programme complete with a schedule, timetables and specific direction. Senator Anderson thought that the complex arrangement of government agency had led to confusion and wasteful duplication.

Outside Criticism

The internecine struggle between the various military and civil departments engaged in space research has long been the subject of criticism both inside and outside of America, but Senator Anderson was far more concerned over the fact that the National Aeronautics and Space Administration's proposed 10 year programme, published in July, did not mention a nuclear rocket mission, and did not look forward to a manned lunar mission until the 1970s. With this in mind Senator Anderson proposed that the following be incorporated into the 10-year programme. He proposed that a test flight of a nuclear rocket prototype, which included facilities for the generation of electricity in outer space by nuclear energy, should be completed by the end of 1964. By the end of the 1960s Senator Anderson wanted to see a manned expedition to the moon utilizing nuclear rockets and nuclear electric power sources. He finally proposed that the maximum development possible in nuclear rockets and nuclear electric power sources (in excess of 1 MW) should be undertaken so that by the end of the 1960s more extensive explorations of the solar system could be prepared.

Progress Made

The Senator thought that the facilities for such a programme could be found in America's national laboratories and industrial installations, and he referred to a recent statement by General Irving Branch, who was responsible for the Atomic Energy Commission's nuclear space activities, that a nuclear propulsion booster could be ready for space flight by the mid-sixties but unfortunately NASA were not anticipating building a vehicle to use such power by that time. Senator Anderson then made a dramatic appeal to America to end its mediocrity in astronautics and urged that the United States be the first to display the value of nuclear power as a tool for space exploration.

In the Senator's statement there was some caustic criticism of the nuclear policies of NASA including the influence that large contracts to private companies was having on policy formation. He also implied that some of the aircraft companies had vested interests in chemical rocket systems which affected research on nuclear energy for rockets. He wanted decisions made on the relative priorities of the nuclear rocket and the huge chemical rockets to avoid costly duplication.

NASA found a champion to defend the charges made by Senator Anderson, in a fellow Democrat, Mr. Overton Brooks, chairman of the House Committee on Science and Astronautics, which has legislative jurisdiction over NASA. Mr. Brooks pointed out the technical difficulties of developing nuclear rocketry and added that people who do not have an overall view of America's space programme cannot appreciate the amount and degree of human achievement involved. This achievement would not, in Mr. Brooks's opinion, be realized merely by appropriating money and by government directive. He gave as an example the years of trial and error which finally produced the ballistic missiles upon which current space missions were completely dependent and added that, space exploration by nuclear propelled rockets would not come with any less effort.

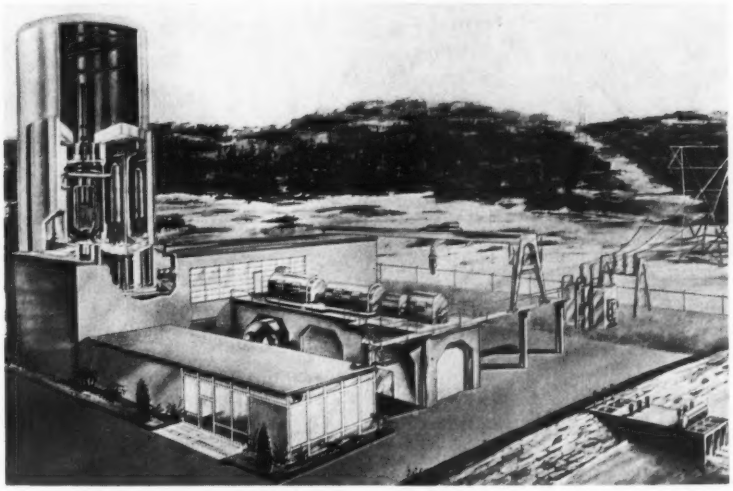
Co-operation Announced

The end of August saw an announcement by the AEC and NASA of the establishment of a joint Nuclear Propulsion Office to integrate the "Project Rover Nuclear Powered Rocket Developmental Programmes" of the two agencies. The AEC would retain primary responsibility for developing all reactors and their components including those for flight missions specified by NASA, while the latter would be responsible for research on non-nuclear components and the integration of nuclear components in the engines and vehicles of rocket systems.

This new office is obviously intended to end the previous "two camp" situation that Senator Anderson had criticised. The Senator's reactions to the formation of the Nuclear Propulsion Office were that, it had only come about after months of delay and he did not appear to be any more hopeful that orders would be speeded up. NASA underlined the need for substantial industrial participation in the space programme, but they did not make it clear how much of the programme was being contracted out to industry at the present time or how much would be in the future

America's H.T.G.C.R.

THE PEACH BOTTOM POWER PLANT



Cutaway view of the 40 MW high temperature gas cooled reactor plant due to come into operation at Peach Bottom, Pennsylvania, in 1963

THE high temperature, gas-cooled, graphite-moderated reactor plant to be built at Peach Bottom, Pennsylvania, by High Temperature Reactor Development Associates Inc., when completed in 1963, will have an electrical design output of 40 MW. Heat output of the reactor will be 115 MW and steam will be generated at the rate of 336,000 lb/hr at a pressure of 1,450 lb/sq.in. and a temperature of 1,000°F.

Fuel for the reactor will be enriched uranium and thorium carbide mixed with graphite in homogeneous compacts. Coolant will be helium gas.

The steam conditions obtainable from the reactor will enable conventional turbine equipment to be used, one of the features of the plant that help to make it an attractive, economic proposition. Other favourable features will be its simplicity and compactness—two factors that will contribute to a reduction in its capital cost. Yet another advantage will be its high thermal efficiency, achieved without compromising the low capital expenditure while at the same time reducing the operating costs.

Interest in the design and construction of a gas-cooled reactor was shown by American industry in 1957 when General Dynamics' General Atomic Division started a theoretical and experimental programme into the development of such a system. Their efforts were later supplemented by design studies undertaken by the Bechtel Corporation.

Tenders in 1958

In 1958 the U.S. Atomic Energy Commission invited tenders from industry for the design, construction and operation of a gas-cooled, graphite-moderated reactor plant. A contract was awarded in 1959 to the Philadelphia Electric Co., and 53 other utilities who had combined forces to form High Temperature Reactor Development Associates Inc. The system chosen by this group was that developed by General Dynamics.

In the initial loading of the HTGR core the fuel elements will be metal-clad, later they will be graphite-clad. Metal cladding will impose a temperature limitation on the fuel surface, resulting in some sacrifice in steam conditions. Even so, the steam temperature of 850°F. and pressure of around 850 lb/sq.in. are high when compared with steam conditions obtainable in other nuclear systems. The corresponding rating when metal clad elements are installed will be 28.5 MW. Graphite clad elements will be introduced into the core during the second loading.

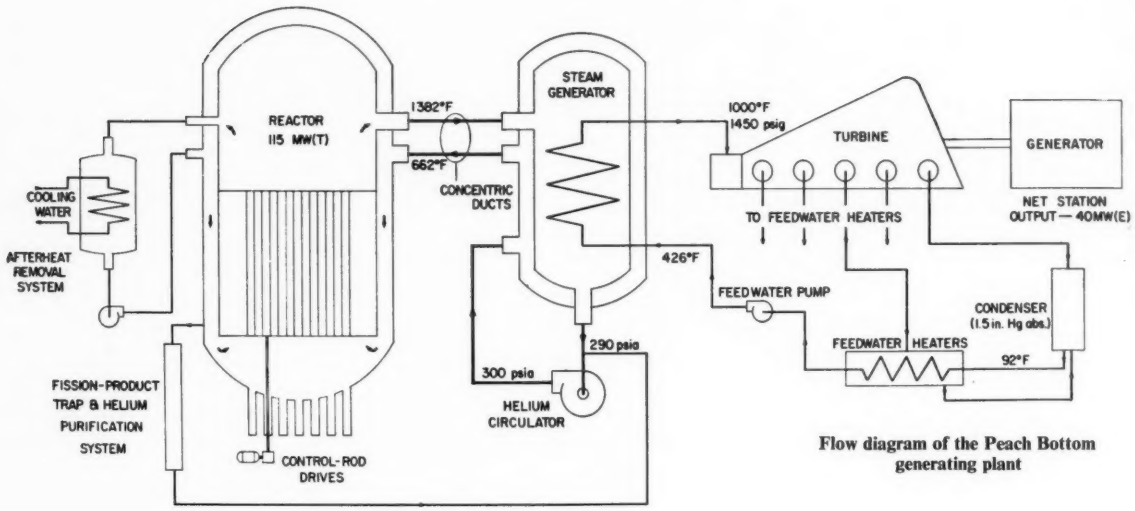
The fuel elements will be 12 ft in length and $3\frac{1}{2}$ in. in diameter. There will be 810 of them in the core, arranged in a closely-pitched equilateral triangular array. There will also be about 40 control rods in the core.

The Gas Flow

Helium gas, the coolant, will be passed into the pressure vessel containing the core through a concentric duct piping. It will then flow axially down the graphite reflector and then up through the fuel elements.

Principal H.T.G.C.R. Parameters

Operating Conditions	
Coolant	Helium
Pressure (atm) ..	20
Inlet temperature ..	660°F.
Outlet temperature ..	1,380°F.
Maximum fuel-surface temperature	2,300°F.
Steam temperature ..	1,000°F.
Steam pressure ..	1,450 lb/sq.in. abs
Net thermal efficiency ..	34.8 per cent.
Reactor thermal output	115 MW
Net electrical power ..	40 MW
Reactor Parameters	
Fissile investment ..	190 kg
Thorium investment ..	1.19 m tons
Core diameter	9.0 ft
Core length	7.5 ft
Core coolant voidage ..	12.8 per cent.
Fuel-element diameter	3.50 in.
Number of fuel elements	810 approx.
Reflector thickness ..	2 ft
Core graphite weight ..	19.5 m tons
Reflector graphite weight	47.7 m tons
Pressure-vessel diameter	14 ft (i.d.)
Pressure-vessel height ..	34 ft
Core graphite/uranium ratio	1,900
Burn up	
Fissions/original fissile atom ..	0.63
Mwd(th)/metric ton of U-235 + Th232 ..	80,900
Core life at 80 per cent. load factor ..	3 years



Flow diagram of the Peach Bottom generating plant

Above the core will be a plenum chamber which will serve as a thermal barrier between the outgoing hot helium and the incoming cool gas and will connect the outgoing gas to the central portion of the concentric piping.

There will be one steam generator, or heat exchanger connected to the reactor. Helium will enter it at a temperature of 1,380°F. and leave it at 600°F. The heat exchanger in its turn will be connected to a turbine-generator.

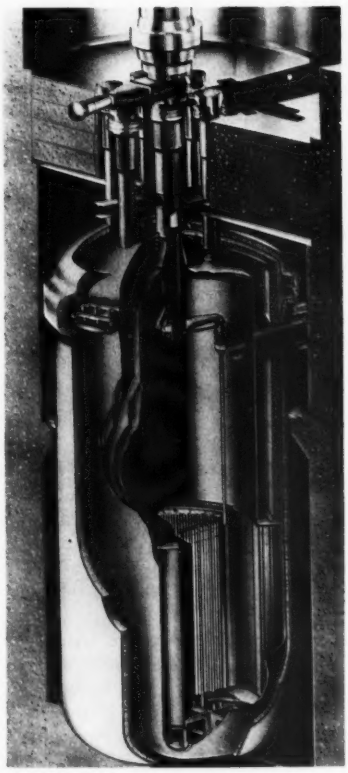
Helium an Advantage

Some of the more important design features of the HTGR which will contribute to its over-all high performance are:—

1. *The use of helium as coolant.* This gas permits freedom of reactor operation at high temperatures without high pressures. Furthermore, helium is an inert gas which permits a choice of economical structural material without the compatibility of the material with the coolant having to be taken into account.

2. *Loose fitting fuel.* The uranium carbide-thorium carbide fuel elements will be contained in loose fitting cans, the surface of which will be heated by means of radiation. The loose fit will isolate the can from possible dimensional changes of the fuel.

3. *Combination of the moderator with the fuel.* A thousand-fold dilution of the fuel atoms by the homogeneously mixed graphite moderator provides a means for the conduction of heat from the fuel particles to a large surface area without the need for a very large number of small fuel elements. The dilution also serves to maintain the structural integrity of the fuel element compacts under irradiation. Because there is less than one part of fuel for approximately every one thousand parts of fuel compact material, no appreciable amount of impairment of structural strength would be expected even in the ideal case of complete burnup of the fuel.



Cutaway section of the HTGC reactor and core

4. *High operating power density.* Adequate heat transfer surface in the core is easily obtained with the HTGR'S rugged fuel elements because, by combining the moderating and heat generating function within the fuel elements, the entire core volume is occupied by fuel elements. The high surface temperature of the graphite clad elements will result in excellent heat transfer to the coolant. This will permit moderate gas pressures, low pumping power, and high core power densities.

Towards Cost Cut

These features open the way to a substantial reduction in capital costs. They will permit the use of a high outlet temperature of the gas-cooled system, eliminating the necessity for very large heat exchangers. The moderate gas pressure and the low stored energy characteristics of the gas coolants will also eliminate the requirement for heavy pressure vessels and thick-wall containment structures.

5. *Concentric flow system for the coolant.* Through the use of concentric inlet and outlet tubes and by directing the inlet coolant down the sides of the reactor vessel, the pressure-sustaining materials of the reactor vessel, ducting and boilers will be in contact with the gas only

at the reactor inlet temperature, thus minimizing the need for expensive steels for high temperature operation.

6. *Elastic fuel element constraint.* The core structural system will embody an elastic form of fuel element constraint, thus allowing for thermal expansion.

7. *Metal-clad fuel elements changeover.* The reactor design has sufficient flexibility to enable the use of metal-clad fuel elements in a core designed to take graphite-clad elements. The metal-clad elements will be installed in the initial core loading. Only a minimum of reactor plant modification will be required to make the changeover to the graphite-clad elements.

8. *Use of uranium-thorium fuel cycle.* The U-235-thorium cycle, with its anticipated long reactivity lifetimes, will make best use of the irradiation damage resistance of the fuel element. High burnup of each core loading is a major objective of the system.

9. *Fission product retention system.* Each HTGR fuel element will contain an outer graphite sleeve in which will be inserted several smaller graphite cylinders containing the uranium-thorium carbide fuel. Each fuel bearing graphite cylinder will be encased in a can of special graphite.

Impermeability Feature

The escape of the fission products from the fuel cans will be minimized by a high degree of impermeability of the graphite can or by application of an essentially impervious coating. The outer graphite sleeve will be of low permeability to further reduce the possibility of escape of fission products to the main helium coolant. Those fission products escaping the inner graphite cans will be swept away in relatively undiluted form by a helium purge stream flowing at a low rate through the annulus between the cans and the outer graphite sleeve. This purge stream will flow to an external fission product trapping system.

10. *Inherent safety of the system.* The high ratio of moderator-material to fuel will provide the HTGR's homogeneous fuel elements with a large heat capacity to protect the reactor core in the event of sudden power rises or changes in the coolant flow. All graphite structures in the reactor are designed to operate at temperatures high enough to prevent any appreciable accumulation of internally stored energy in the graphite during irradiation.

Prompt Braking

The reactor will have a negative temperature coefficient which, by virtue of the homogenoueous fuel moderator elements will act promptly. This means that, if for some reason, the reactor temperature should suddenly rise, the multiplication of neutrons will slow down and serve as a brake on the chain. Further safety will be provided by the fact that the entire reactor core and steam generating system will be enclosed in a pressure-tight containment vessel.

RADIATION SAFETY

(*Continued from page 519*)

It is usually sufficient to arrange a simple smear check which will come into contact with the source container when the capsule is replaced in its storage container and to arrange that before withdrawal of the source for use, these contact smears are checked on a suitably sensitive counter.

There are thousands of sealed sources in use for a variety of purposes in establishments where no other type of radioactive material is used. In the majority of cases there is no one with any experience of contamination and no suitably sensitive instrument designed to detect contamination. The very real danger of serious contamination to personnel which may be going on over a period of some months where only " sealed sources " are in use, is not widely appreciated and certainly not recognized in most codes of practice nor provided for in protective installations.

It is reasonable that all sources whether in use or not should be visually inspected via a simple system of mirrors and telescopes once a month. Where sources are in daily use, the smear test for contamination which is carried out at each withdrawal of the source should be supplemented by a weekly visual inspection. Each storage container may be easily arranged near a system of mirrors to facilitate remote visual inspection as conveniently as possible.

Where sources and machines are mobile, simple regulations can ensure that each source must be accounted for in a source register held by the health physics officer or his deputy *before* each transit of the source. For example, requiring the return to stores during transfer between sites may often involve a double period of transit exposure and involve " unnecessary and avoidable" exposures. Instead, it should be the responsibility of the person who withdraws a source or machine from its " approved site or storage " to keep the health physics officer or his deputy informed of the purpose and intended itinerary.

The probable hazards must be estimated and arrangements for the necessary monitoring and recording of dosage to personnel must be made. It is usually possible to ensure that radiation at one metre from a transit shield and at the end of any handle (or at the position of the person accompanying the transit) is less than continuous working level of radiation dose-rate adopted by the establishment.

Whenever the hazard area is vacated at the end of the day (or at any time) the health physics officer must be notified if any source remains outside its "approved storage." Use of a source outside its " approved storage " or " approved site " requires a series of recommendations with respect to barriers, safety interlocks, warning notices, etc. In many circumstances, security and fire risks may require a detailed map or manifest of all sources outside " approved storage " while the area is vacated—overnight or weekend—and may require a regular patrol by watchman, fireman or security officer.

(*To be continued*)

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NUCLEAR NOTES

Agencies Combine

THE International Atomic Energy Agency and the European Atomic Energy Agency are to co-operate with each other in activities and programmes in which they have a common interest. They will consult each other in order to harmonize their efforts as far as is appropriate in the light of their respective world-wide and regional responsibilities. Co-operation will also take the form of reciprocal representation at their respective regular annual meetings and at other meetings where matters of mutual interest are considered. Subject to arrangements which may be necessary for the safeguarding of confidential information, the agencies will keep each other fully informed on projected activities and programmes and, where convenient and appropriate, there will be an exchange of personnel, materials, services, equipment and facilities. The agreement covering the terms of co-operation has been approved by both the OEEC Council, parent body of the ENEA, and the General Conference of the International Atomic Energy Agency. A similar co-operative agreement has also been made between the IAEA and the Inter-American Nuclear Energy Commission.

Stockholm Success

A LARGE number of instruments related to reactor control and development, together with a display of the industrial uses of radioisotopes, were shown at the Commercial Exhibition, recently held in the Osterman Marble Halls, Stockholm. About one-third of the total space was occupied by a self-contained British section, the centrepiece of which was the UKAEA stand which provided a central point for the 15 British firms which had their own stands grouped round the Authority's exhibit. The exhibition was organized in conjunction with the four-day Instruments and Measurements Conference. Some 800 delegates from 16 countries attended this conference, and of the 140 papers given, 37 were British, 35 Swedish, 29 German, 15 were from the U.S.A., and 24 from other countries. The commercial exhibition was visited by Sir William Cook and later by Lord Craigton, Minister of State for Scotland, accompanied by Britain's Ambassador to Sweden, Sir John Coulson. Lord Craigton's visit formed part of the goodwill mission to promote industrial and tourist exchanges between Sweden and Scotland. Towards the end of the exhibition reports from Stockholm indicated that attendance had been heavy and that there had been many visitors from Swedish firms and other technical organizations.

A.G.R. Contract

PLESSEY Nucleonics Ltd., have received an order from the U.K. Atomic Energy Authority for the supply of all the nuclear instrumentation for the Authority's advanced gas-cooled reactor at Windscale. The complete instrumentation assembly—consisting mainly of standard instruments currently in production—will incorporate all the equipment necessary for complete reactor control and safety during start-up, normal running and shutdown conditions.

U.S.-Euratom Research

THE U.S.-Euratom Joint Research and Development Board recently announced that a total of 45 proposals for research and development work amounting to approximately $78m. have been accepted for contract negotiation within the Community and within the United States. Twenty-eight Community and 10 United States organizations are represented by the work authorized, much of which involves close collaboration between Community and U.S. industrial groups.

N-Research in Africa

WORK on the construction of the £500,000 nuclear research institute of the Universities of Stellenbosch and Cape Town, South Africa, will probably start in 1961. Surveying of the 300-acre site near Faure (between Cape Town and Somerset West), where the institute will be built, has begun. The land was sold to the universities by the Union Department of Lands for £1. Professor P. B. Zeeman, Professor of Experimental Physics at the University of Stellenbosch, has reported that so far £135,000 has been donated towards the institute (£100,000 by the Cape Provincial Administration) but that construction could not begin until the fund stood at £200,000. However, the universities had received several "substantial promises." Professor Zeeman said that, if there were a short fall on the total sum, it was hoped that the Union Government would step in and make up the deficit. The South African Atomic Energy Board would supply most of the running expenses.

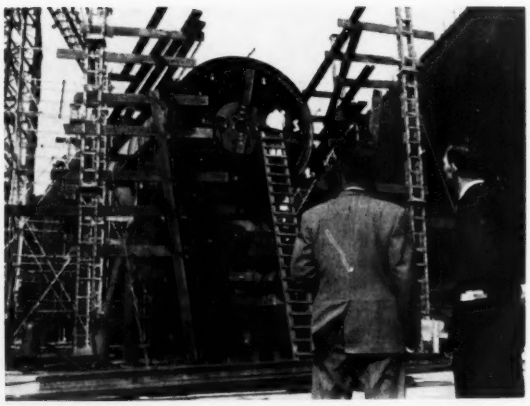
Industrial "Challenge"

SEVENTY organizations, including reactor builders, component suppliers, manufacturers of equipment associated with radiation applications and service organizations, are exhibiting at the 1960 AtomFair-West, San Francisco, to be held in conjunction with the winter meeting of the American Nuclear Society (December 12th-15th) and the annual conference of the Atomic Industrial Forum (December 14th-16th). The theme of the AIF conference is "Nuclear Frontiers—a challenge to industry," and will cover such topics as the role of nuclear energy in space explorations; the impact of public attitudes on atomic energy progress; problems in industry-government relations; advanced nuclear technology; international atomic developments; and progress in radiation and radioisotope application.

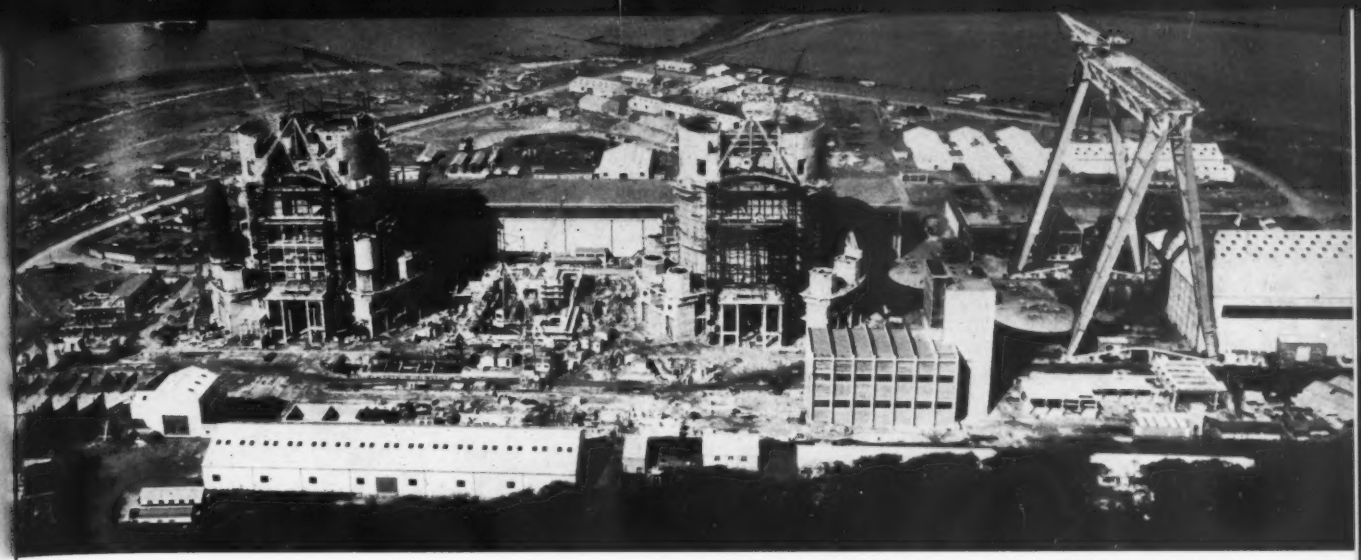
Food Congress, 1962

SEPTEMBER 18th to 21st, 1962, are the dates fixed for the First International Congress on Food Science and Technology, which will be held in London under the presidency of Lord Rank of Sutton Scotney. All aspects of food technology will be covered by the papers and there will be visits to research and education establishments as well as to food manufacturers. Chairman of the executive committee is Professor H. D. Kay, CBE, FRS.

Progress on N-Submarine



Britain's first nuclear-powered submarine, *HMS Dreadnought*, under construction at the Barrow-in-Furness yards of Vickers-Armstrongs, Ltd. The vessel was recently launched by HM the Queen



Two Years to Go

Since work on the 360 MW Hunterston nuclear power station restarted in January, following labour disputes, progress has been steady. The emphasis on construction has now moved away from civil engineering to mechanical engineering and it is hoped that the labour problems associated with the assembly of the pressure vessels and steam raising plant have now been resolved. The first reactor, the pressure vessel for which has just been stress-relieved, is due to be on load in the 1962-63 winter and reactor No. 2, the pressure vessel of which is now under fabrication, is due to be ready in the autumn of 1963

For Biological Shields

BERRY WIGGINS & Co., Ltd., have produced with the co-operation of Borax Consolidated, Ltd., a range of boronated bitumen compounds. Of these, " Kingsnorth Compound No. 2028 " (patent applied for) has already found commercial use as a biological shield in nuclear reactors. " Kingsnorth Compound No. 2028 " contains a bitumen soluble boron compound which is free from problems associated with sedimentation. The presence of boron in combination with hydrogen in this new material will, when used at the recommended thicknesses, ensure complete attenuation and absorption of slow neutrons. Sample quantities are available.

Core for A.S.T.R.A.

DELIVERY was recently made by the Texas Instruments subsidiary, M. & C. Nuclear, Inc., of the first core loading of 36 nuclear fuel elements to power ASTRA (Adapted Swimming Pool Tank Reactor) located at the Austrian Nuclear Reactor Centre in Seibersdorf, near Vienna. ASTRA is Austria's first reactor, and will be among the largest research reactors in Europe when full power of 12 MW is reached. It will be used jointly by Austria and members of the International Atomic Energy Agency.

Yugoslav T.R.I.G.A.

THE U.S. Government has extended grants totalling $350,000 to the Federal People's Republic of Yugoslavia to assist in furthering the peaceful uses of atomic energy, including an inherently safe TRIGA reactor to be used in Yugoslavia's nuclear training and research programme. The Yugoslav Government has selected a 100 kW(t) above ground TRIGA Mark II specially adapted to a wide range of research and training applications for installation at the Josef Stefan Nuclear Institute at Ljubljana and is scheduled to be in operation in 1962. The versatile TRIGA reactors were conceived and developed by General Atomic Division of General Dynamic Corporation. Some 20 TRIGAs in both above ground and below ground models are in use or soon will be operating on five continents for training, research, isotope production, as well as for medical, agricultural and industrial applications.

Company's Sales Up

SALES and earnings for High Voltage Engineering Corporation, the manufacturers of particle accelerators, in the first half of 1960 were higher than in any earlier six-month period, according to Mr. Denis M. Robinson, the president. Sales amounted to $4,551,571, an increase of 30 per cent. over sales of $3,521,218 for the corresponding period a year ago.

Control Method Studied

THE American Babcock & Wilcox Co. has been awarded a $1,223,500 contract by the U.S. Atomic Energy Commission for the study of the physics aspects of a new method of nuclear reactor control originated by the company. Called the " spectral shift " method of control, it will use a mixture of heavy and light water to act both as a reactor system coolant and as a moderator to control pressurized water reactors. Its use is expected to increase the life of water reactor cores, increase the efficiency of fuel consumption, and replace portions of the costly and intricate control rod systems now in use. Work on the new reactor control concept has been going on since 1957 in the company's atomic energy division in Lynchburg, Va. The AEC contract for an expanded physics programme to develop the concept further will continue until October, 1961.

Spanish Study

A DESIGN study for a multi-purpose nuclear power plant has been completed for the Junta de Energia Nuclear, an agency of the Spanish government, by Atomics International, a division of North American Aviation, Inc. The atomic plant under study would include facilities for nuclear research in addition to having a generating capacity of 30 MW(e). The contract follows an earlier conceptual design study conducted by Atomics International for the Junta. Included in the new study is an increase in power from 20 MW to 30 MW. Cost estimates of building the reactor plant also were determined. The reactor would be cooled by an organic fluid and deuterium oxide would be the moderator.

Reactors for Carrier

THE U.S. atomic powered aircraft carrier *Enterprise* will use eight pressurized water reactors developed and designed by Westinghouse Electric Corporation under the direction of and in technical co-operation with the Naval Reactors Branch of the Atomic Energy Commission. The vessel will have a speed of over 25 knots. " It is estimated that atomic power will multiply by some 20 times the distance the *Enterprise* can travel at full speed without refuelling as compared with the conventional oil-fired carriers. Dependence on far-flung bases and auxiliary ships is thus minimized," says Philip Ross, general manager of the Bettis laboratory. While the *Enterprise* propulsion system is unique in naval history both in design and power, its prototype already has proved its feasibility, Mr. Ross pointed out. In 1956 the U.S. Atomic Energy Commission began construction of a land prototype nuclear power plant for the *Enterprise*. The prototype plant consists of the machinery for one of the four shafts of the carrier and includes two nuclear reactors. The prototype is located at the United States Naval Reactor Facility in the Idaho desert and is housed in an exact replica of a section of the ship's hull, complete in every detail. " An historic milestone in naval nuclear propulsion was achieved in September, 1959, when the two prototype reactors of this ' desert ship ' were operated in tandem to drive a single propeller shaft at full power," Mr. Ross said.

NUCLEAR NOTES

TV at Harwell

CLOSED-CIRCUIT television has been brought into service at Harwell as an additional safety measure for the high-power materials testing reactors PLUTO and DIDO. This equipment will enable the inside of the reactor buildings to be viewed from an external control position if it is ever necessary to evacuate the buildings as a result of an accidental release of radioactive materials. PLUTO and DIDO are the most powerful reactors at Harwell, and are used to study and make accelerated tests on the effects of irradiation on materials and fuels used in the construction of reactors. They are also used for producing radioisotopes and for basic research. The reactors incorporate safety devices which will automatically shut them down in any event of malfunctioning. Each is constructed inside an airtight steel building, which would contain any radioactive material accidentally released from the reactor itself, or from the fuel elements or experimental equipment when being unloaded from it. In the event of such an accident the reactor building would be evacuated, and although the reactor cannot then be run, certain essential operations can be carried out remotely from a heavily shielded emergency control room some distance away. The recently installed television circuit will make it possible to view the interior of the reactor building from the emergency control room and thus to plan and control emergency operations inside the building. If it is necessary for workers to enter the active area they may be instructed and shown what to do before they enter, and will then be able to carry out the maximum work in the limited period during which it would be safe for them to be exposed to radiation. Use can also be made of the television system under everyday conditions by the inclusion of a screen in the normal control room inside the reactor building. This enables the control staff to view and co-ordinate any special work in progress on the reactor top which is not visible from the control room. There are two cameras for each reactor, but if required for a particular purpose all four could be used with one system. The picture from any camera can be selected at will. Pye Ltd., of Cambridge, supplied the equipment.

Safety Booklet

INCLUDED in the Ministry of Labour HM Factory Inspectorate report on "Electrical Accidents and Their Causes—1959" is a section devoted to "Electrical Instrumentation and Control of Nuclear Reactors." It outlines the problems associated with the control of a reactor and briefly describes the design and construction of safety circuits. The report, which is available from the Stationery Office, costs 5*s.* 6*d.*

Bulgarian Reactor

THE construction of the IRT-1000 thermal nuclear reactor of the atomic research establishment of the Institute of Physics in Sofia, Bulgaria, is nearing completion. The reactor will be used for studies in radiation chemistry, biology and genetics and will produce radioactive isotopes for use in medicine, industry and other fields.

Yankee Contract

TELEFLEX, Inc., of North Wales, Pennsylvania, the American associate of Teleflex Products, Ltd., of Basildon, Essex, have recently installed a Teleflex flux mapping system for the 110 MW BWR reactor of the Yankee Atomic Electric Company's plant at Rowe, Massachusetts.

Pakistan Grant

THE U.S. Government is contributing $350,000 towards the cost of a nuclear research reactor project being undertaken by the Pakistan Atomic Energy Commission near Rawalpindi, W. Pakistan. The reactor, part of the Pakistan Institute of Nuclear Science and Technology, will operate under the supervision of the Pakistan Atomic Energy Commission, and include laboratories, counting room, health physics office, shops, library, museum, auditorium and radioactive materials storage area. It will be available to a number of Pakistan colleges, universities and laboratories for training and research. The research staff will include a number of Pakistan scientists who have studied in the U.S.A.

Kahl Reactor Ready

THE first atomic power plant in West Germany has been completed at Kahl on Main, two years after work started. A 15 MW boiling reactor, it will be operating later this year, mainly for experimental purposes.

Firm's Atomic Orders

TELEFLEX Products, Ltd., the remote control engineers of Basildon, Essex, are to supply 60 sets of damper gear each for the two reactors of the Berkeley power station. For a reactor building at Winfrith AEE, Teleflex are supplying window gear control for the reactor physics block and the workshop and maintenance block.

I.A.E.A. General Conference

BY 44 votes in favour to 14 against, the general conference of the International Atomic Energy Agency at its recent fourth annual meeting in Vienna approved the adoption of a set of safeguard regulations recommended by the Agency Governors. There were five abstentions. The regulations, which are opposed by the Soviet Union and other Communist countries, are designed to ensure that no fissile materials supplied by the Agency are diverted for use in weapons and they include provisions for the inspection of reactor plants.

The conference unanimously approved two agreements between the Agency and two inter-governmental organizations. These are the European Nuclear Energy Agency and the Inter-American Nuclear Energy Commission of the Organization of the American States. (For further details of these agreements, see under separate item.)

Welcoming the acceptance of the ENEA agreement, Mr. J. L. Weinstein, ENEA Counsellor, emphasized that informal co-operation between the two agencies had already taken place in the fields of health and safety and legal liability. He felt, however, that close collaboration and consultation on all matters were essential if the IAEA and ENEA were successfully to accomplish their aim of promoting the development of the production and use of atomic energy for peaceful purposes.

The general conference also adopted a resolution authorizing the board of governors to invite other inter-governmental nuclear energy organizations to be represented at next year's meeting of the conference.

The regular budget of $6,186,000 for 1961 was approved, as also was an operational programme amounting to $1,800,000 and a working capital fund of $2,000,000.

Accepting the Agency's provisional regulations for the transport of radioactive materials, the conference recommended that member states of the Agency use them as a basis for relevant national regulations. As the same time the Agency was urged to continue carrying out research and preparing regulations, manuals and codes of practice relating to health and safety.

The Agency was requested to study and report on the question of establishing an international centre for theoretical physics. It was also asked to explore the possibilities of co-operating in the field of radiation and neutron standards with the International Bureau of Weights and Measures and other appropriate international organizations.

Voluntary contributions pledged to the general fund of the Agency by member countries amounted to approximately $1m. The delegate of the United States of America stated that the United States contribution would again be $750,000. $500,000 would be paid unconditionally. The U.S. Government would match, when the General Fund reached $1m., contributions in excess of that sum, dollar for dollar, until a total of $1,500,000 had been reached. The U.S. pledge is the same as that offered last year. The U.S. delegate stated that if the matching portion of his country's contribution continued to be unused or only partially used, the Government of the United States would have difficulty in making a similar matching offer in future years.

The delegate of the Soviet Union stated that his country had contributed to the Agency's activities in the form of 70 cost-free fellowships and the services of 30 experts. Besides, the U.S.S.R. had contributed 500,000 roubles ($125,000) which had not been used. In this connection his Government had the impression that the Agency did not want to use this contribution.

ISOTOPE WORLD

A Supplement devoted to the Subject of Radioisotopes

ISOTOPES IN GREECE AND AFRICA

I.A.E.A. Report on Uses and Scope

EARLIER this year the International Atomic Energy Agency sent a preliminary assistance mission to Greece, the Ivory Coast, the Federation of Mali, Morocco, Tunisia and the Sudan. Its purpose was to collect technical information on the nuclear activities and plans of these countries, advise them on the development of their peaceful atomic energy programmes, and to help them in formulating requests for Agency assistance. As might be expected, the mission found that what work in the nuclear energy field was being undertaken was with radioisotopes. Also, that there was plenty of scope for further use of these products.

This was the fifth mission of its kind, the earlier four having visited a number of other countries in Asia, Africa, Latin America and Central Europe. As in previous cases, this mission had been despatched at the request of the countries concerned.

Among establishments visited which impressed the mission was the Alexandra Hospital in Athens where radioisotope work of a wide range and high standard is undertaken. The laboratory facilities available, the great variety of techniques in use and the quality of the work done are such that the hospital could be developed as a valuable training centre for the medical applications of radioisotopes. Some teaching of radioisotope techniques has already been undertaken, but the potentialities should be more fully explored.

Isotope Centres

The mission also visited the Anti-Cancer Hospital and the Evangelismos Hospital. At the first a small radioisotope unit has been formed and a new radioisotope centre is to be built in the near future. A cobalt-60 teletherapy unit is also being installed. At the Evangelismos Hospital a small but well-designed radioisotope centre has already been constructed and equipped. Medical radioisotope work could be extended to other centres as well, provided that they already have adequate basic laboratory services and other facilities.

At the Democritus Centre, headquarters of the Greek AEC, the mission discussed the setting up of an Institute of Biology and Experimental Medicine. It found that the designs for the proposed new laboratories to be housed in the institute were in principle sound, but urged that detailed consideration should be given to the problem of staffing.

While visiting medical institutes and hospitals in the Ivory Coast, the mission noted the interest shown by the scientific personnel in the medical applications of radioisotopes, both in therapy and diagnosis. Before the establishment of a Faculty of Medicine and the completion of a new medical centre in the country, it would be premature to initiate work with unsealed sources of radioisotopes, although provision should be made for such work at the proposed new centre.

The existence of a well-established Department of Radiology at the Abidjan Central Hospital does make it possible to introduce Co60 teletherapy. Should the Government consider such a possibility, the mission would recommend assistance by the Agency in the training of staff and in the installation of the necessary equipment.

Mali not Ready

At the various departments of the Faculty of Medicine in the University of Dakar, the Hôpital Le Dantec and other hospitals and medical research institutes in the Federation of Mali, the mission was impressed by the high quality of the work done in spite of the inadequacy of staff. However, because of the present shortage of skilled staff in all branches of medical work and the urgent need for basic medical services, the initiation of a large-scale programme of medical isotope work should not be undertaken at the present time.

If the fundamental problem of lack of trained staff can be overcome, the Hôpital Le Dantec in Dakar could suitably house a centre for clinical diagnostic and therapeutic work with isotopes. There is a plan for the setting up of an anti-cancer centre which would include facilities for radium therapy, deep X-ray therapy and Co60 teletherapy. Such a centre could well be a nucleus for the future development of diagnostic and therapeutic work with unsealed radioisotopes.

The Institut Marchoux at Bamako would like to carry out radioactive tracer studies of the distribution and metabolism of drugs used in the treatment of leprosy. If the appropriate labelled compounds could be obtained, it would be useful to pursue these investigations.

In Morocco, any large-scale development of the medical applications of atomic energy would be premature at this stage in view of the lack of skilled staff available for specialized training in these techniques. However, it is not too early for the Government to consider plans for the introduction of such techniques as diagnostic tests with unsealed radioisotopes, radiotherapy by internal administration of unsealed radioisotopes and teletherapy with sealed radioisotopes.

Two projects might be considered independently or in conjunction: (*a*) the setting-up of a clinical radioisotope unit to undertake first diagnostic work and later both diagnostic and therapeutic work with unsealed radioisotopes; and (*b*) the establishment of a Co60 or Cs137 teletherapy unit. This will need careful planning in regard to staff, buildings and equipment; in particular a trained physicist will be necessary to undertake radioactive assay or radiation dosimetry and to be responsible for radiation protection.

Anti-Cancer Plans

There is also a plan for the establishment of an anti-cancer centre, which will include a Co60 teletherapy unit. The staff for such a centre should include a trained medical physicist to undertake radiation dosimetry and to be responsible for radiation protection. In the beginning, the centre should also receive the advice and assistance of an expert radiologist.

The Sudan Government intends to establish in Khartoum, with the support of the World Health Organization (WHO), a radiation and isotope centre designed primarily for the diagnosis of cancer and its treatment by radioisotopes and X-ray teletherapy. In future, this might serve as a centre for work with unsealed sources of radioisotopes in other branches of clinical medicine and research. However, in view of the limited number of skilled staff, such developments should not be initiated until radioisotope teletherapy has been established.

It is understood that the services of a radiotherapist and of a medical physicist will be supplied by WHO to initiate radiotherapeutic work at the institute and that a radiotherapist is undergoing training overseas. The training of a counterpart medical physicist is essential for the success of the institute. and Agency assistance in this respect would be desirable.

Farming Problems

While at the Democritus Centre in Greece, the mission discussed several special problems concerning the uses of isotopes in agriculture. Among the topics of immediate interest were:

(*a*) A programme of research aimed at the eradication of the olive parasite by male sterilization.

(*b*) The use of radioisotopes to investigate crop adaptation to the various soil regions, especially from the point of view of fertilizer requirements.

(*c*) A programme relating to the production of mutation in crop plants through the use of radiation.

(*d*) A proposal to subject the larvae of certain animal parasites to radiation as the basis for vaccine.

(*e*) The measurement of Sr90 in milk and vegetables.

Agricultural research in the Ivory Coast is well organized, and five specialized institutes and one basic organization, the Office de recherche scientifique et technique d'outre-mer (ORSTOM) amply cover all present requirements. Up to the present no work has been undertaken with radioisotopes or radiation, apart from a current study on insect tagging.

Discussions revealed some problems which could profitably be tackled with nuclear techniques, and the mission suggested that as a first step elementary nuclear training should be given to some of the scientists. Later, the services of an expert could be made available to

assist in the planning and setting up of the radioisotope laboratory which is to be established at the ORSTOM and in initiating research programmes.

Water Tracing for Rice

In the Federation of Mali, the major problem is to develop traditional agriculture with special emphasis on rice, groundnuts and cotton. Much progress has already been made with conventional methods. A problem which could be tackled with radioisotopes is phosphorus uptake by plants and phosphate fertilization. This is particularly important in view of the considerable deposits of phosphates in the Federation.

Information on soil water would also be useful in developing rice cultivation in regions where irrigation waters are saline; measurements of soil water using nuclear methods should, however, be deferred until some scientists and technicians have been trained.

Agriculture in Morocco consists of two main enterprises: crop production—with emphasis on cereals—and animal breeding. For the first, water is the main problem. Research centres are few and the first step to be taken in applying atomic energy to agricultural research is to increase the number of trained staff. An expert should be assigned for six months, with the necessary equipment, to study soil water. This work would benefit not only the agriculturalists who specialize in cereal production, but also foresters in their efforts to regenerate the forests of cedars and cork trees.

Cattle breeding suffers severely from tick-borne disease which damages the skins of cattle. The mission suggested a study of the economic merits of eradication through male sterilization, and further investigations depending upon the results of the study.

Soil Humidity Problem

Tunisia, though possessing a few highly qualified engineers, has an inadequate number of engineers and technicians. As soon as possible, engineers should be given short-term courses of specialized training in nuclear agricultural techniques, and training courses of at least one year's duration should be given to technicians.

The main agricultural problem in Tunisia is measurement of soil humidity. An Agency expert on this subject was due to arrive there shortly. The expert could also assist the laboratory of the Botanical and Agricultural Institute of Tunisia in its studies of the phosphorus problem, which is an important one in Tunisia.

The most important economic aspect of agriculture in the Sudan is that of cotton production. Long-fibre cotton is grown under irrigation over an area of 800,000 hectares. The annual production of 500,000 tons of cotton fibre is good, but might be increased by the application of advanced agricultural research techniques.

At present the main problem is considered to be effective irrigation in the cotton-growing region which has a high clay content, and the mission was of the opinion that nuclear techniques could be used for measuring soil water and porosity.

The Sudan Government proposes to send a physicist to Harwell to supplement his training in the use of radioisotopes and radiation in agricultural research. The mission thought that a research contract in this subject would be useful. After this preliminary work, it would also be desirable to assist the research station at Wad Medani in studies of phosphorus migration in soils and of phosphorus uptake by cotton.

(Extract from report of the mission published in the "IAEA Bulletin.")

STERILIZATION PLANT
Cobalt-60 Radiation

FOR continuous large-scale sterilization of pre-packed medical and surgical goods or of the contaminated raw materials for the textile industries, Vickers-Armstrongs (South Marston) Ltd. have designed and developed a cobalt-60 irradiation plant. It incorporates the latest advances in sterilization techniques developed by the United Kingdom Atomic Energy Authority at Wantage and Risley.

The plant is designed to take a gamma ray source with a maximum strength of 500,000 curies. Materials can be sterilized at the rate of between 90,000 and 120,000 lb/week, according to their density.

Materials to be irradiated are presented to the cobalt source by means of a continuous monorail conveyor. This is designed to ensure that each package receives the same amount of radiation.

Water for Storage

The cobalt is housed in a concrete cell and while the plant is not in operation is it lowered into a tank of water. Biological shielding is provided to prevent the spread of radiation and there is a system of interlocks to prevent entry to the cell while the source is in use.

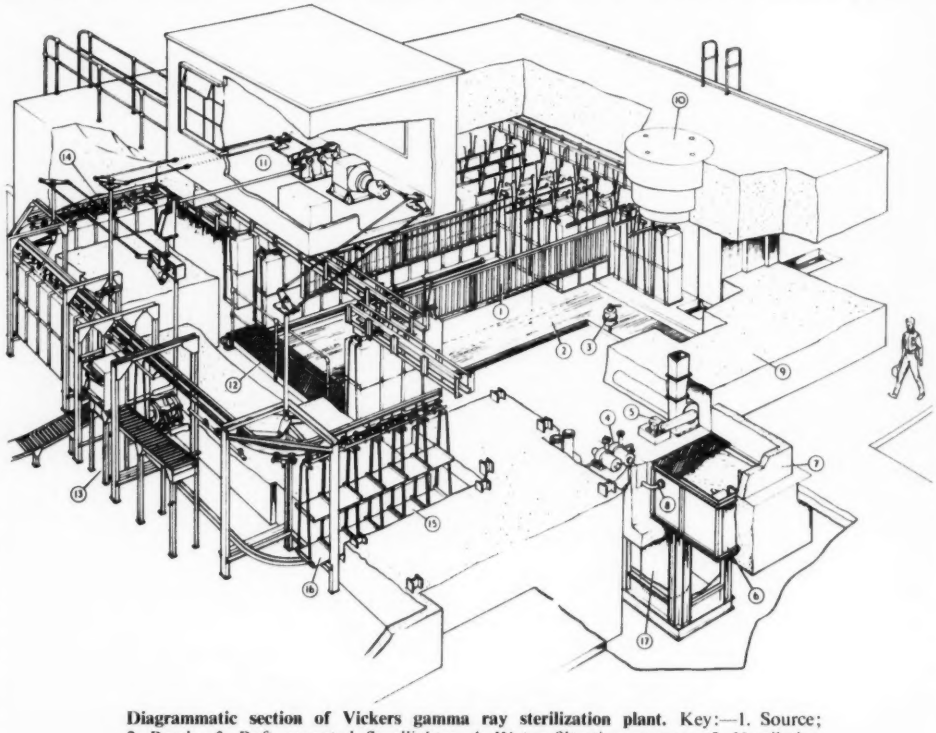
Filtration equipment for use in conjunction with the water in the storage pond is provided and it is said that the efficiency of this equipment is such as to enable the most stringent waste-water disposal requirements to be met. A filtered ventilation system ensures frequent changes of air within the plant.

Twice Round

The gamma emitting source is contained in two plaques mounted within the cell. Packages and other materials for sterilization are loaded into carriers which convey them into the cell. Here they are conveyed on a monorail and are moved around a multi-pass system on either side of the source plaques. Each package passes through the system twice; first in an upper position on the carrier and then in the lower position, thus the resultant irradiation dose will be uniform throughout the package.

Outside the irradiation cell an automatic transfer mechanism moves the completely irradiated package to the output conveyor, transfers the partly irradiated package to the lower position, and introduces a new package to the upper position on the monorail carrier.

The sterilized packages can be passed straight through the carrier labyrinth to emerge at the load/unload escalator, or may be stored in a post-sterilization magazine.



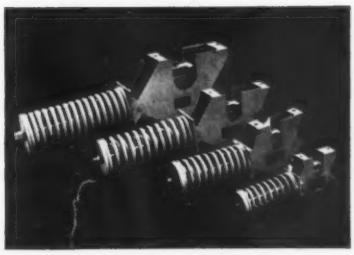
Diagrammatic section of Vickers gamma ray sterilization plant. Key:—1. Source; 2. Pond; 3. Raft mounted floodlights; 4. Water filtration pumps; 5. Ventilation unit; 6. Make up tank; 7. Main plant room; 8. Weir tube; 9. Shielding; 10. Roof plug; 11. Traversing drive mechanism; 12. Rail mounted servicing platform; 13. Load/unload and escalator transfer station; 14. Carrier entry labyrinth; 15. Carrier exit labyrinth; 16. Package carrier; 17. Flask

"I'm a belt and braces man, myself"

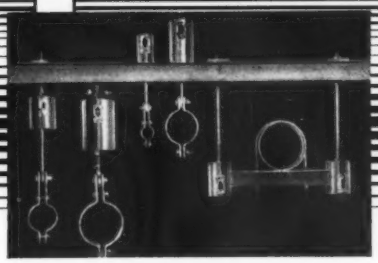
"Because I wear both, my mates reckon I'm a bit of a pessimist! But when it's a matter of essential support I'd rather be safe than sorry. Likewise, I've rigged enough to know that pipework suspended from Gensprings is never going to give any trouble. They use Gensprings on the big nuclear stuff!

This small one just above my head is an M2 Constant Support Hanger. There's a range of sizes to deal with loads from 315 lb. to 97,800 lb. Maximum deviation—if you need it this exact—can now be guaranteed at not more than 2%.

Then there are the Variable Supports for jobs less critical than those needing "Constants", and then again there are Sway Braces for damping out shock and vibration. I'm beginning to sound like the catalogues that Vokes Genspring will be glad to send you!"



Vokes Genspring 'M' Range Constant Support Hangers for supporting pipework and other high temperature equipment such as heat exchangers, furnace walls, condensers, etc. The constant supporting effort is equal to the weight of the pipework irrespective of thermal movements.



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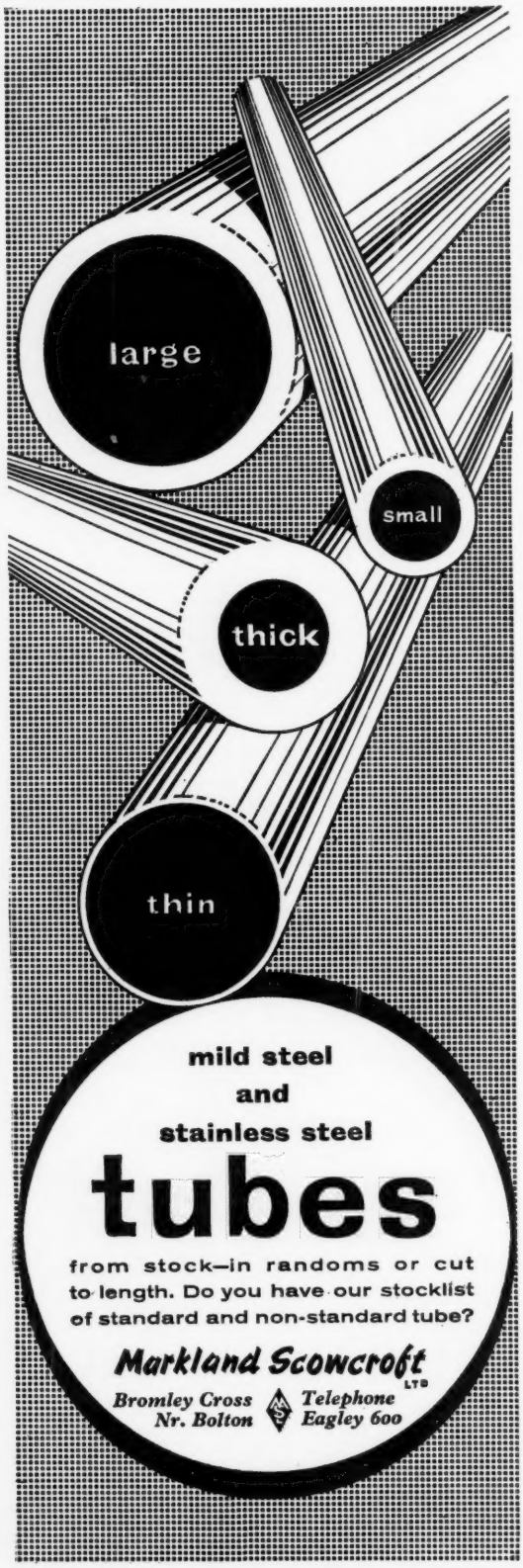

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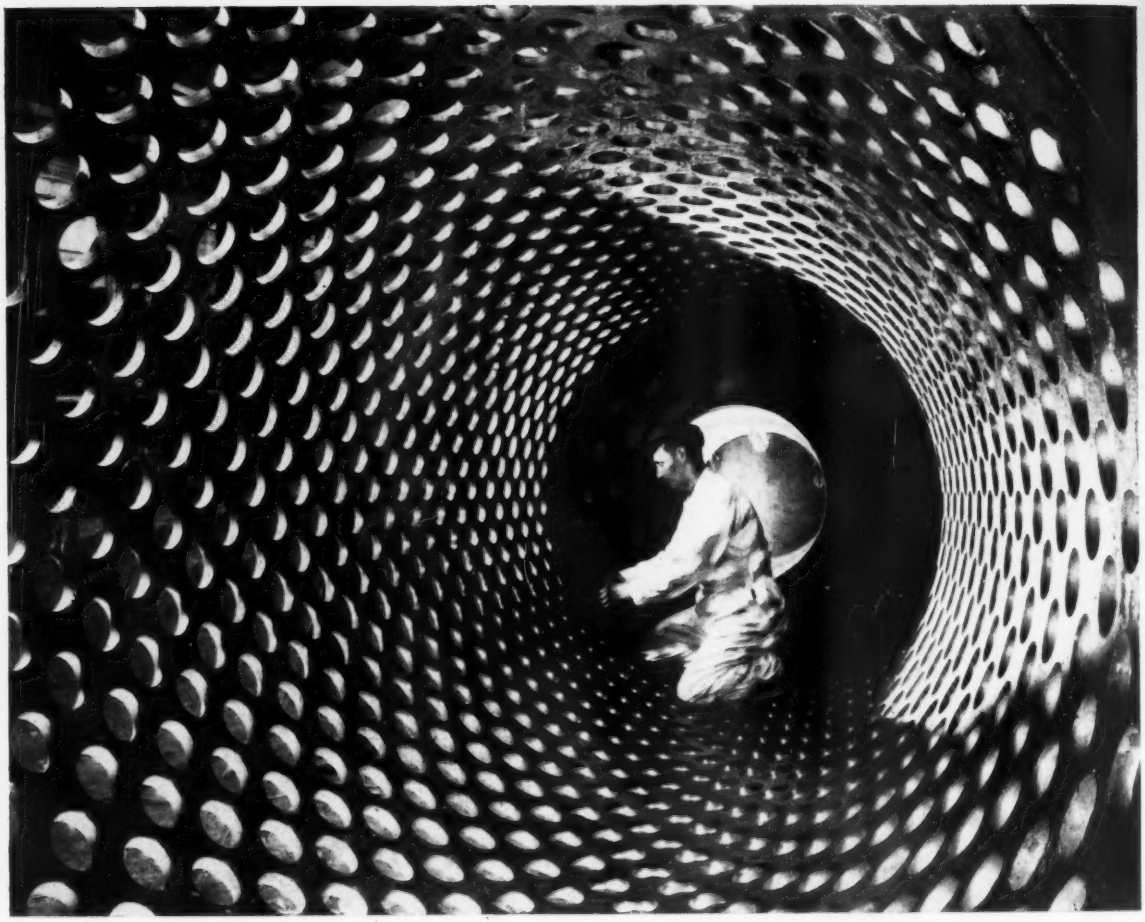

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